Industry & State Level Value Added and Productivity Decompositions

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Value added decomposition

- Parametric and non-parametric estimation of production frontiers
- A recent decomposition proposed by Diewert and Fox (2017)
  - Free Disposal Hull (FDH) and index number theory
  - Rule out technical regress
  - A non-parametric approach involving only observable data

Value added decomposition

- Value added decomposition for Australian market sector industries
  - 12 selected industries and 16 market sector industries
  - Decomposition at an aggregate level and an industry level
  - Sectoral explanations for Australian TFP change
- Simple enough to be implemented by national statistical offices
  - Data cubes from Australian Bureau of Statistics
  - R package: dfvad

Defining the optimal output value

- Cost constrained value added function

$$R^t(p, w, x) = \max_{y,z}\{p \cdot y : (y, z) \in S^t; w \cdot z \leqslant w \cdot x\}$$

- Unit cost function

$$c^t(w, p) = \min_s \left\{ \frac{w \cdot x^s}{p \cdot y^s} : s = 1, \cdots, t \right\}$$

Defining the optimal output value

- Rewrite the cost constrained value added function

$$R^t(p, w, x) = \max_s \left\{ p \cdot y^s \frac{w \cdot x}{w \cdot x^s} : s = 1, \cdots, t \right\}$$
$$= \frac{w \cdot x}{c^t(w, p)}$$

- A sequential approach which rules out technical regress

Explanatory factors

- Net output price indexes

$$\alpha(p^{t-1}, p^t, w, x, s) = \frac{R^s(p^t, w, x)}{R^s(p^{t-1}, w, x)}$$

- Input quantity indexes

$$\beta(x^{t-1}, x^t, w) = \frac{w \cdot x^t}{w \cdot x^{t-1}}$$

Explanatory factors

- Input mix indexes

$$\gamma(w^{t-1}, w^t, p, x, s) = \frac{R^s(p, w^t, x)}{R^s(p, w^{t-1}, x)}$$

- Returns to scale

$$\delta(x^{t-1}, x^t, p, w, s) = \frac{R^s(p, w, x^t)/R^s(p, w, x^{t-1})}{w \cdot x^t / w \cdot x^{t-1}}$$

$$= 1$$

Explanatory factors

- Growth in value added efficiency

$$e^t = \frac{p^t \cdot y^t}{R^t(p^t, w^t, x^t)} \leqslant 1$$

$$\varepsilon^t = \frac{e^t}{e^{t-1}}$$

- Technical progress

$$\tau(t-1, t, p, w, x) = \frac{R^t(p, w, x)}{R^{t-1}(p, w, x)}$$

Straightforward decomposition

- Value added growth decomposition

$$\frac{p^t \cdot y^t}{p^{t-1} \cdot y^{t-1}} = \alpha^t \cdot \beta^t \cdot \gamma^t \cdot \varepsilon^t \cdot \tau^t$$

- TFP growth decomposition

$$\begin{aligned} TFPG^t &= \frac{p^t \cdot y^t / p^{t-1} \cdot y^{t-1}}{\alpha^t \cdot \beta^t} \\ &= \gamma^t \cdot \varepsilon^t \cdot \tau^t \end{aligned}$$

A weighted average industry approach

- Törnqvist explanatory factors: $\lambda \in \{\alpha, \beta, \gamma, \varepsilon, \tau\}$

$$\ln \lambda^{t\bullet} = \sum_{k=1}^{K} \frac{1}{2}(s^{kt} + s^{k,t-1}) \ln \lambda^{kt}$$

- Approximation of value relatives

$$\begin{aligned}
\ln\left(\frac{v^t}{v^{t-1}}\right) &\approx \sum_{k=1}^{K} \frac{1}{2}\left(s^{kt} + s^{k,t-1}\right) \ln\left(\frac{v^{kt}}{v^{k,t-1}}\right) \\
&= \sum_{k=1}^{K} \frac{1}{2}\left(s^{kt} + s^{k,t-1}\right) \ln\left(\alpha^{kt}\beta^{kt}\gamma^{kt}\varepsilon^{kt}\tau^{kt}\right) \\
&= \ln \alpha^{t\bullet} + \ln \beta^{t\bullet} + \ln \gamma^{t\bullet} + \ln \varepsilon^{t\bullet} + \ln \tau^{t\bullet}
\end{aligned}$$

Establishing a benchmark

- $t = 1$

$$A^1 = 1, B^1 = 1, C^1 = 1, E^1 = 1, T^1 = 1$$

- $t > 1$

$$A^t = \alpha^t A^{t-1}, B^t = \beta^t B^{t-1}, C^t = \gamma^t C^{t-1}$$
$$E^t = \varepsilon^t E^{t-1}, T^t = \tau^t T^{t-1}$$

- Level value of productivity

$$\begin{aligned} TFP^t &= \frac{p^t \cdot y^t}{p^1 \cdot y^1 \cdot A^t \cdot B^t} \\ &= C^t E^t T^t \end{aligned}$$

Australian market sector

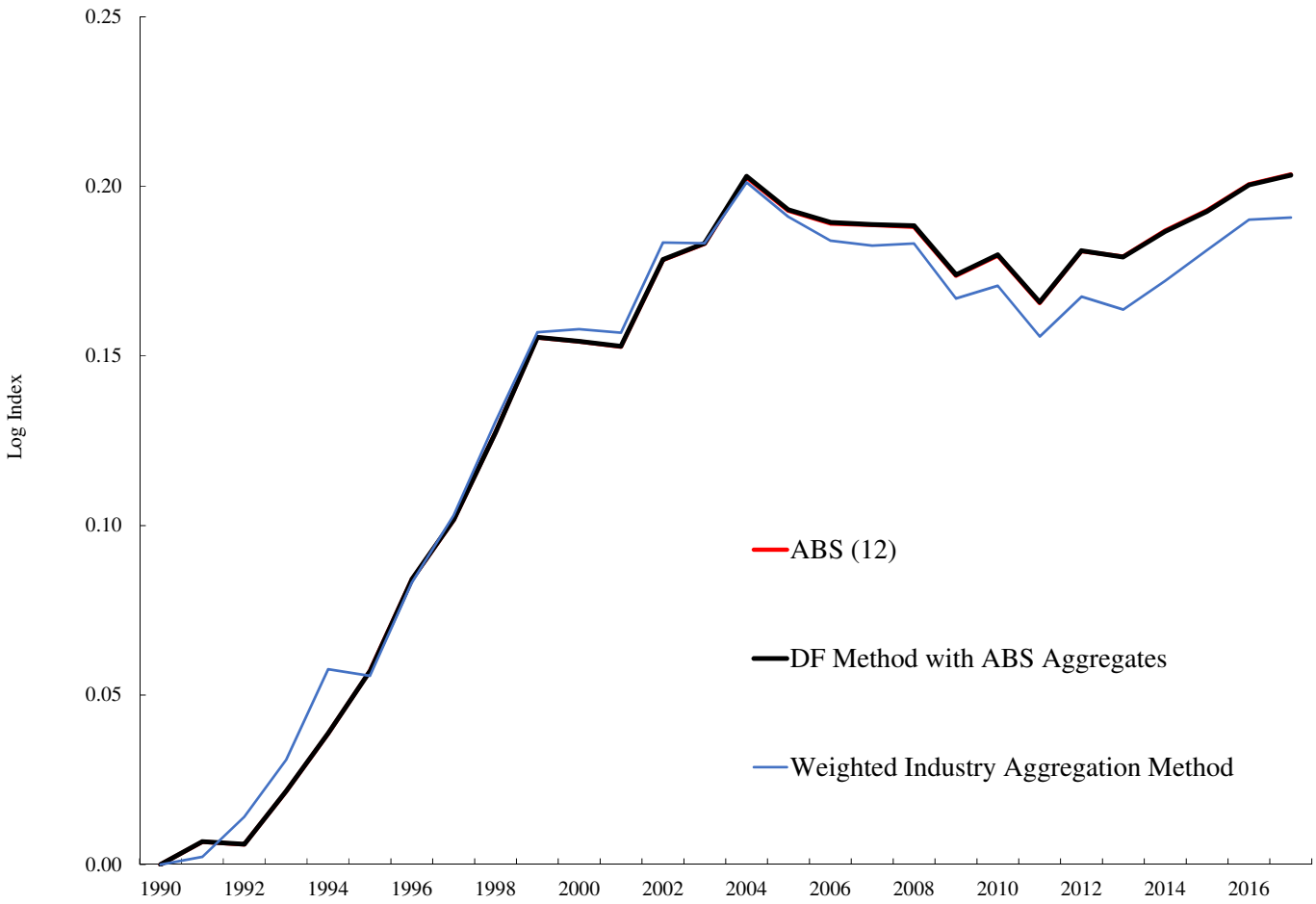
- 16 industries with productivity data available 1994/95-2016/17 (July-June years)
- 12 industries with productivity data available 1989/90-2016/17 (July-June years)
- Concerns about measurement problems and research periods

Australian market sector

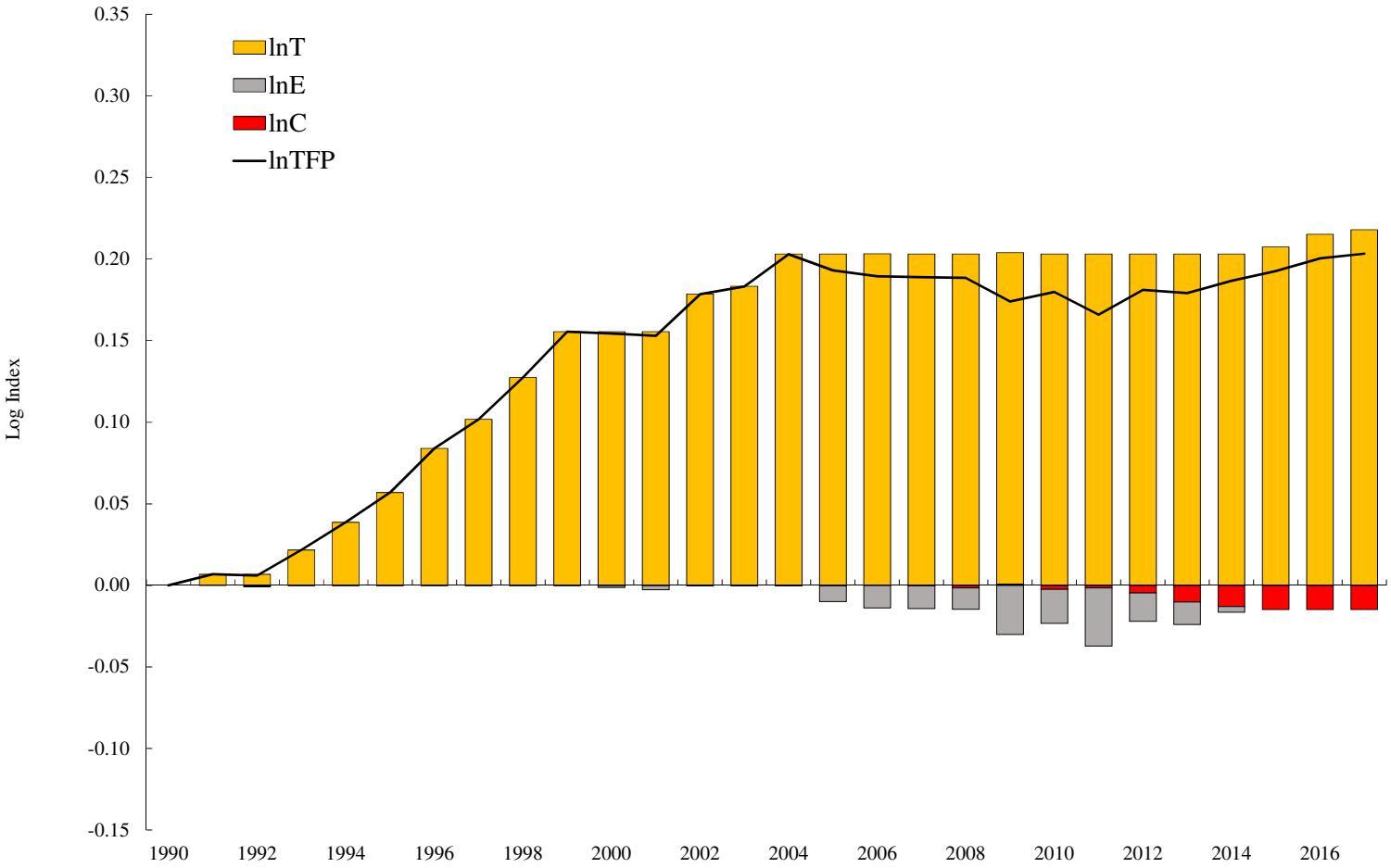
Table 1: Industry classification of the market sector in Australia

Division	Industry
A	Agriculture, Forestry and Fishing
B	Mining
C	Manufacturing
D	Electricity, Gas, Water and Waste Services
E	Construction
F	Wholesale Trade
G	Retail Trade
H	Accommodation and Food Services
I	Transport, Postal and Warehousing
J	Information, Media and Telecommunications
K	Financial and Insurance Services
L	~~Rental, Hiring and Real Estate Services~~
M	~~Professional, Scientific and Technical Services~~
N	~~Administrative and Support Services~~
R	Arts and Recreation Services
S	~~Other Services~~

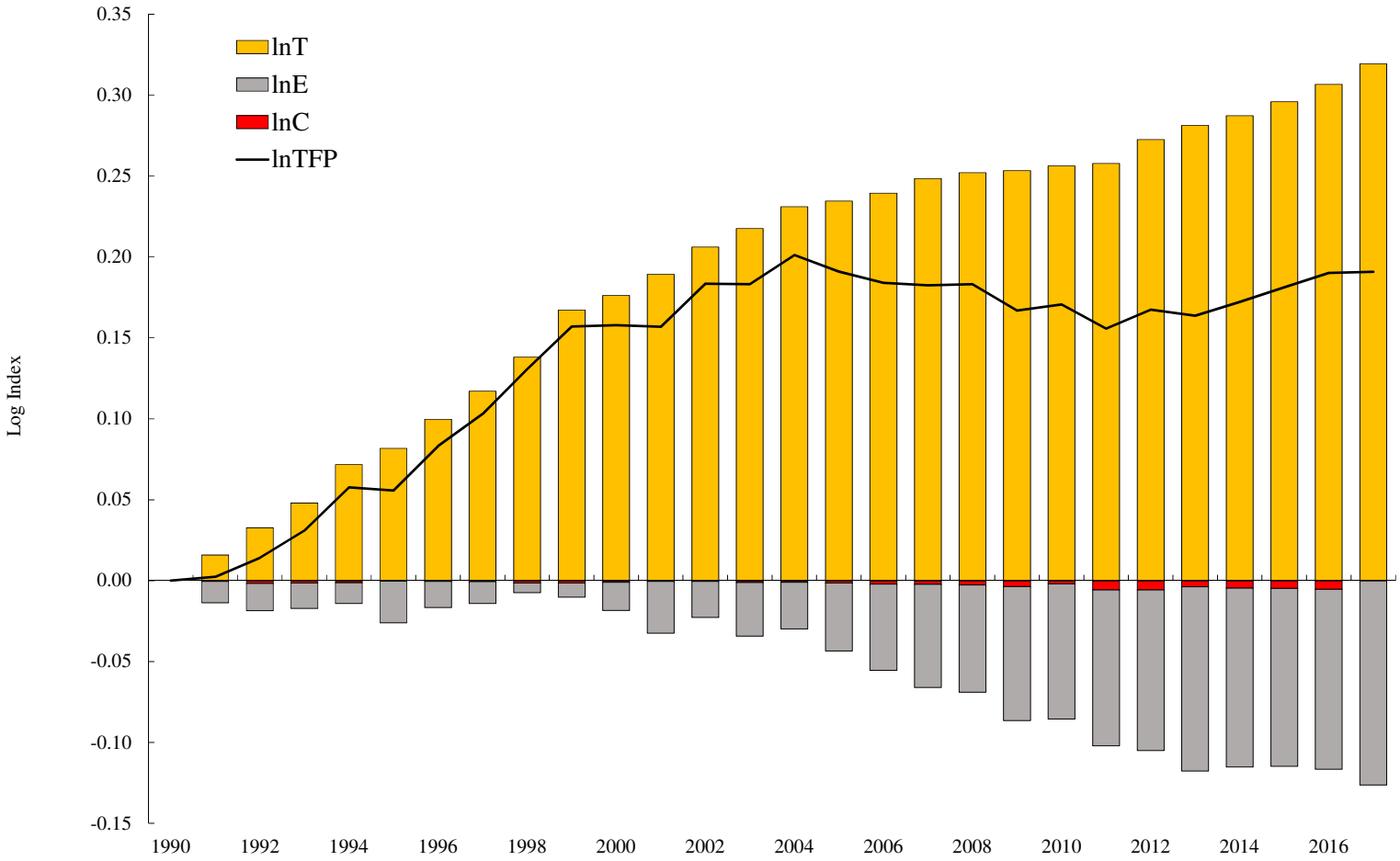
Productivity of 12 selected industries



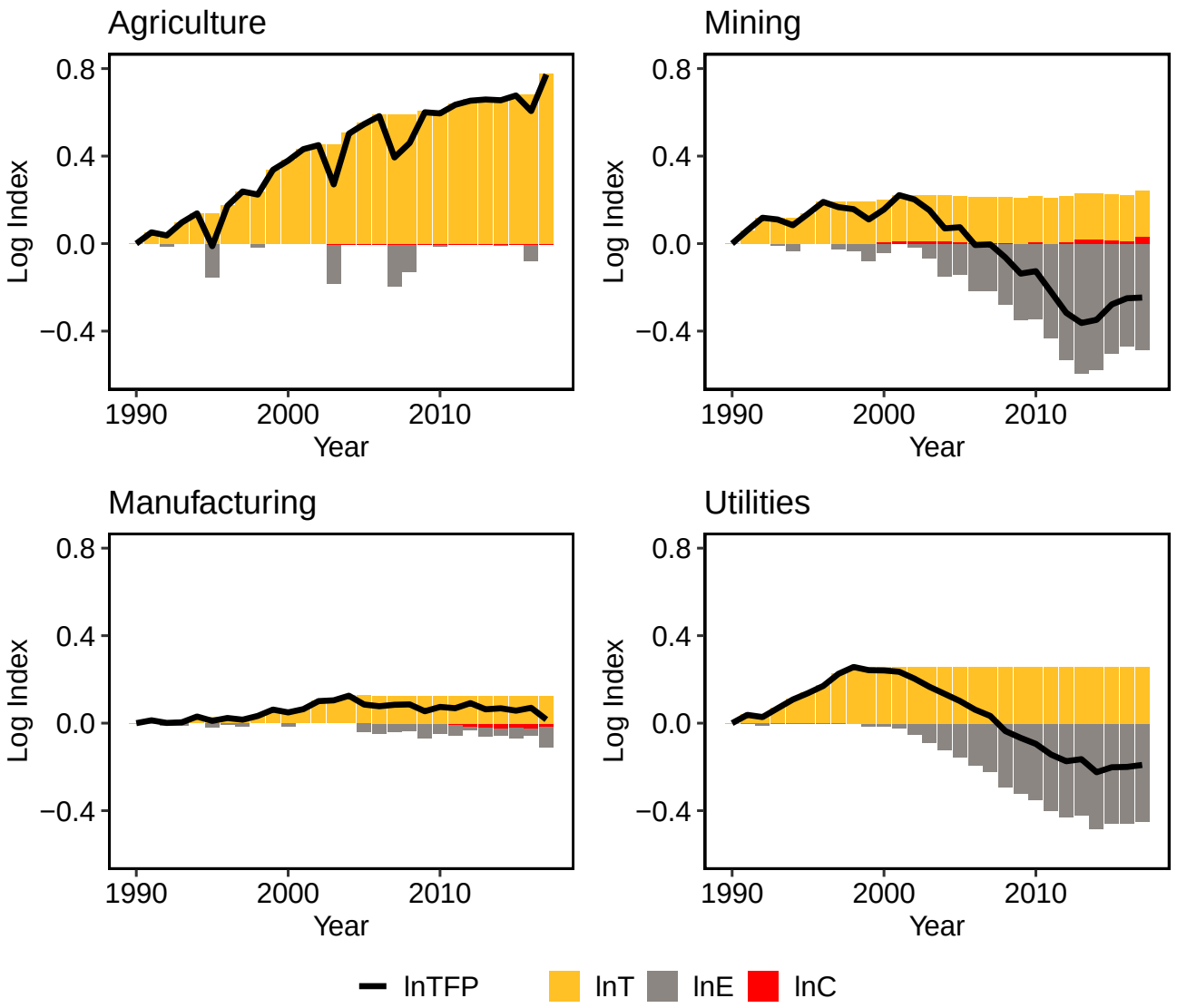
DF Method with ABS aggregates



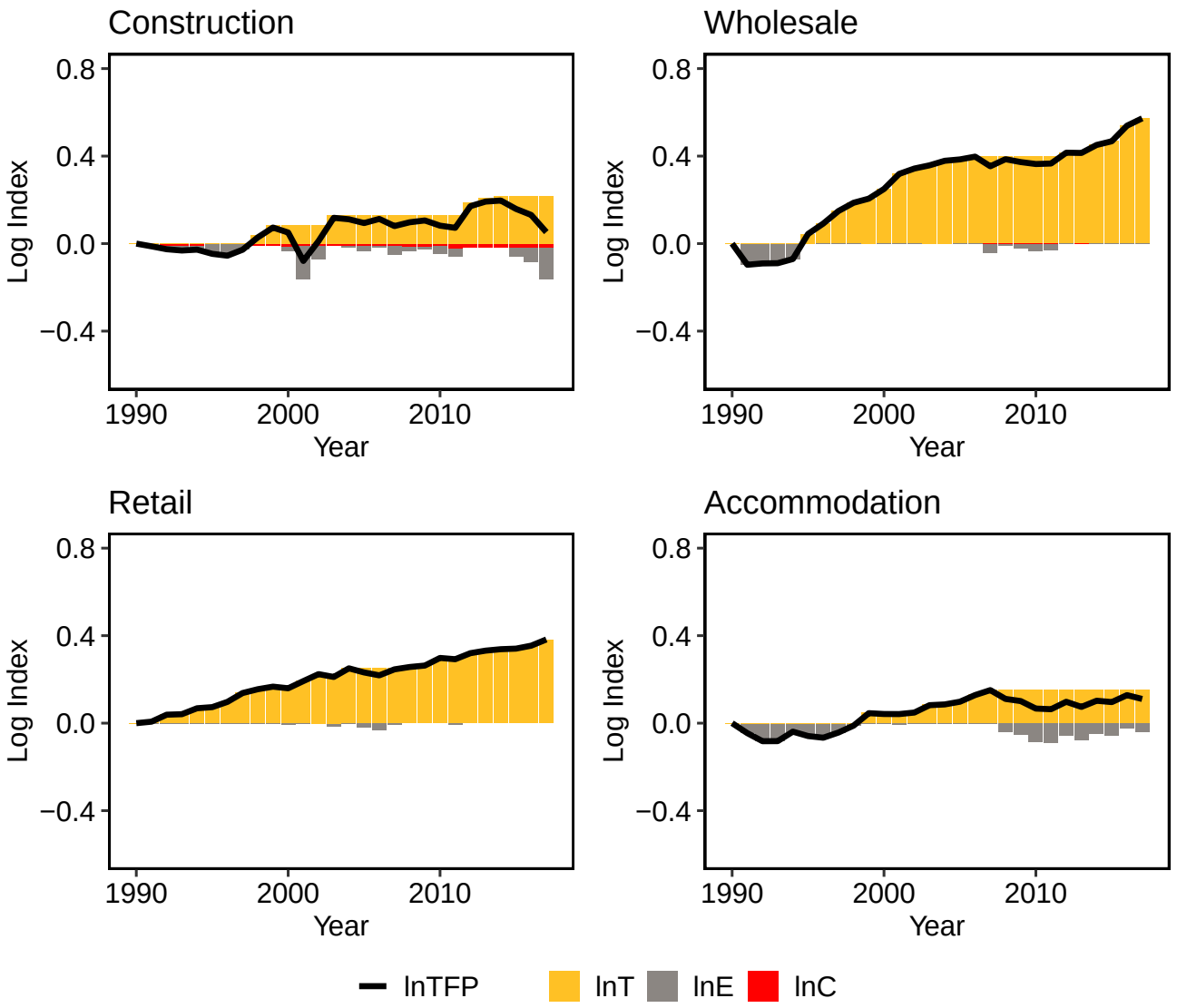
Weighted industry aggregation method



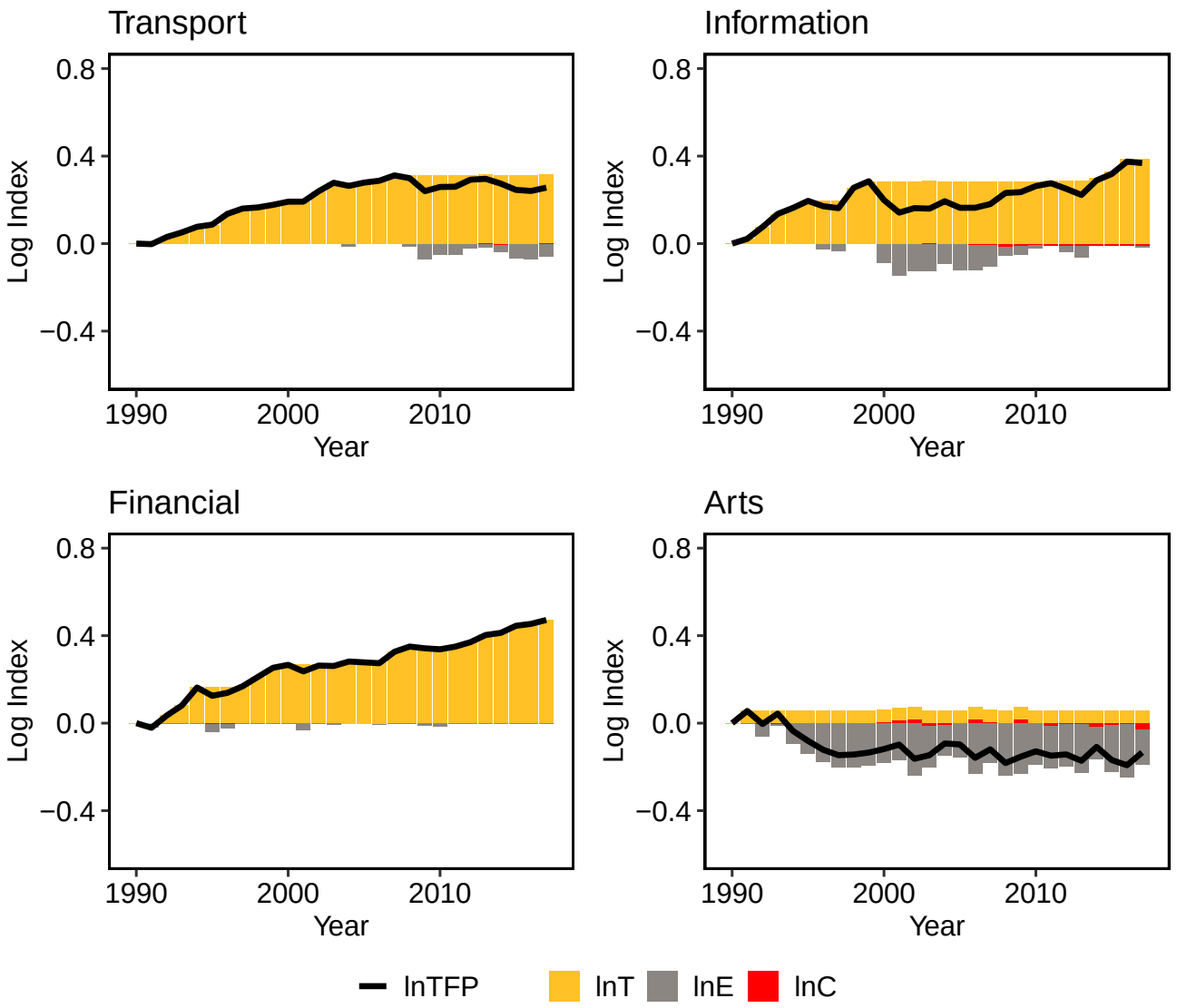
Divisions A–D



Divisions E–H



Divisions I–K, R



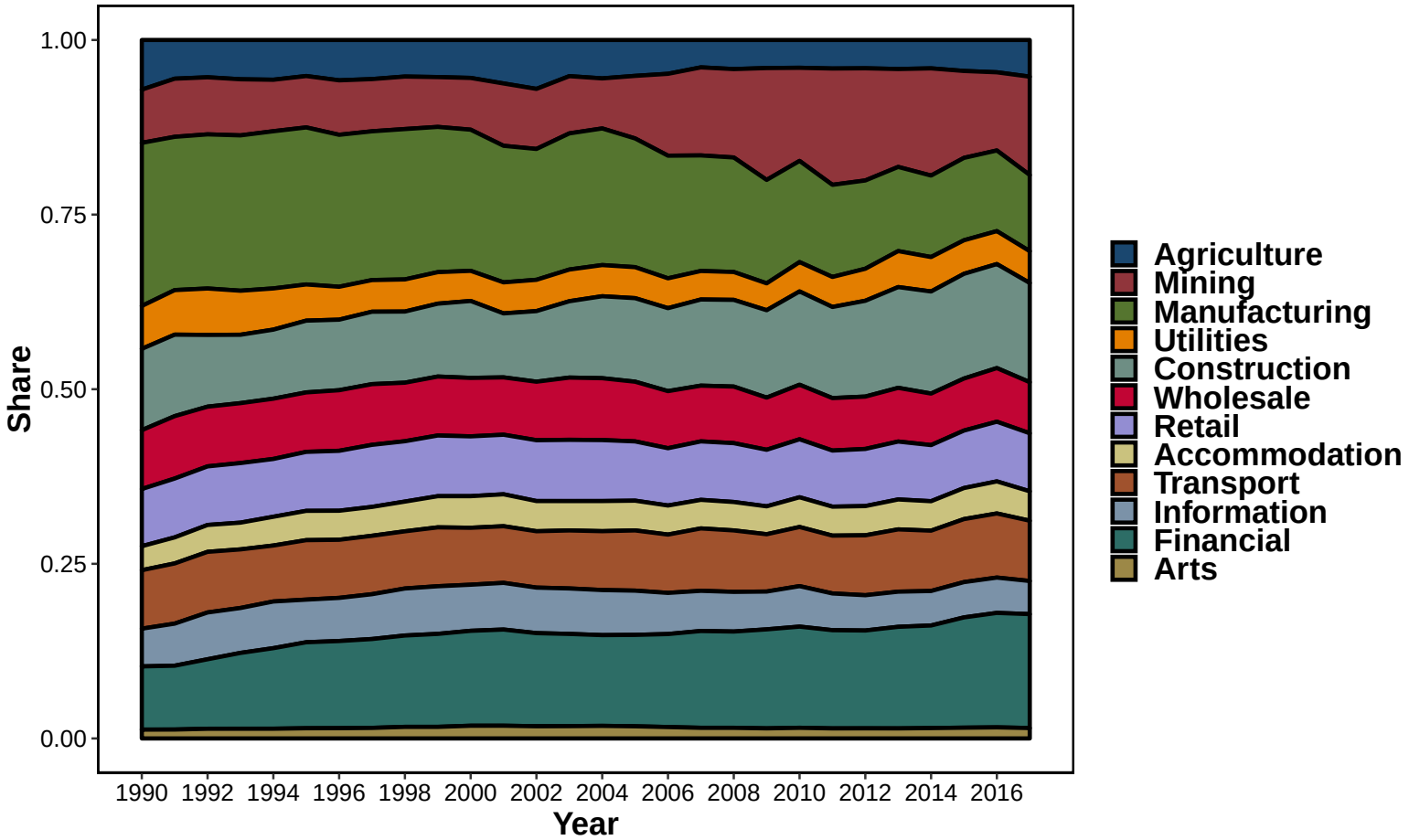
Thoughts on the industry results

- Only 4 industries showed considerable technical progress beyond 2004
  - Agriculture, forestry and fishing
  - Retail trade
  - Wholesale trade
  - Financial and insurance services
- Some industries showed little technical progress even earlier than the 2004 peak
  - Mining (1996)
  - Electricity, gas, water and waste services (1998)
  - Information, media and telecommunications (1999)
  - Arts and recreation services (1991)

Thoughts on the industry results

- The amount of inefficiency for some industries was huge
  - Manufacturing
  - Mining
  - Electricity, gas, water and waste services
  - Accommodation and food services
  - Arts and recreation services
- Some of this inefficiency is probably real and some of it probably indicates mismeasurement of inputs and outputs

Industry contribution: value added shares



Industry contribution: aggregation

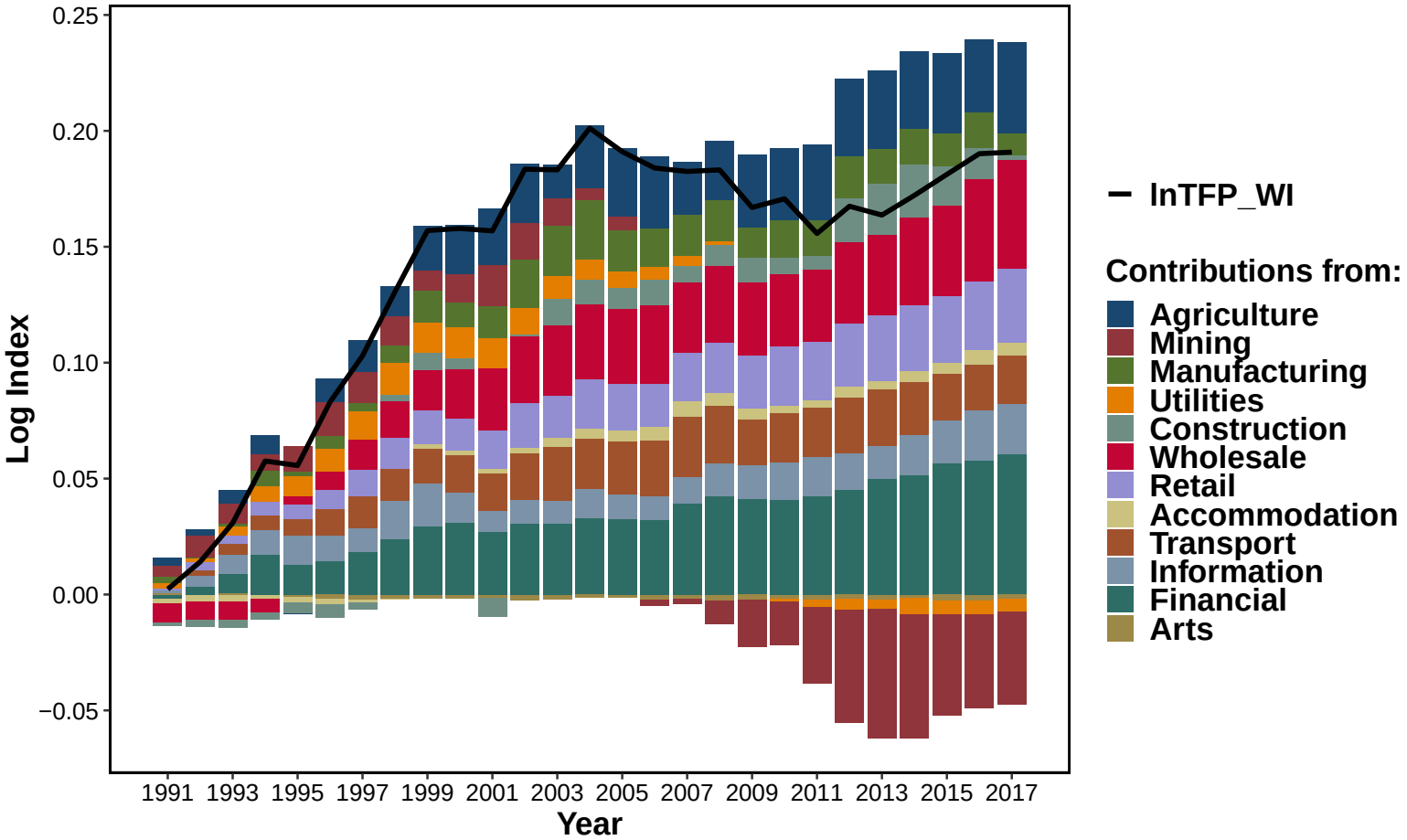
- The weighted average industry approach

$$\ln \lambda^{t\bullet} = \sum_k \frac{1}{2}(s^{kt} + s^{k,t-1}) \ln \lambda^{kt}$$

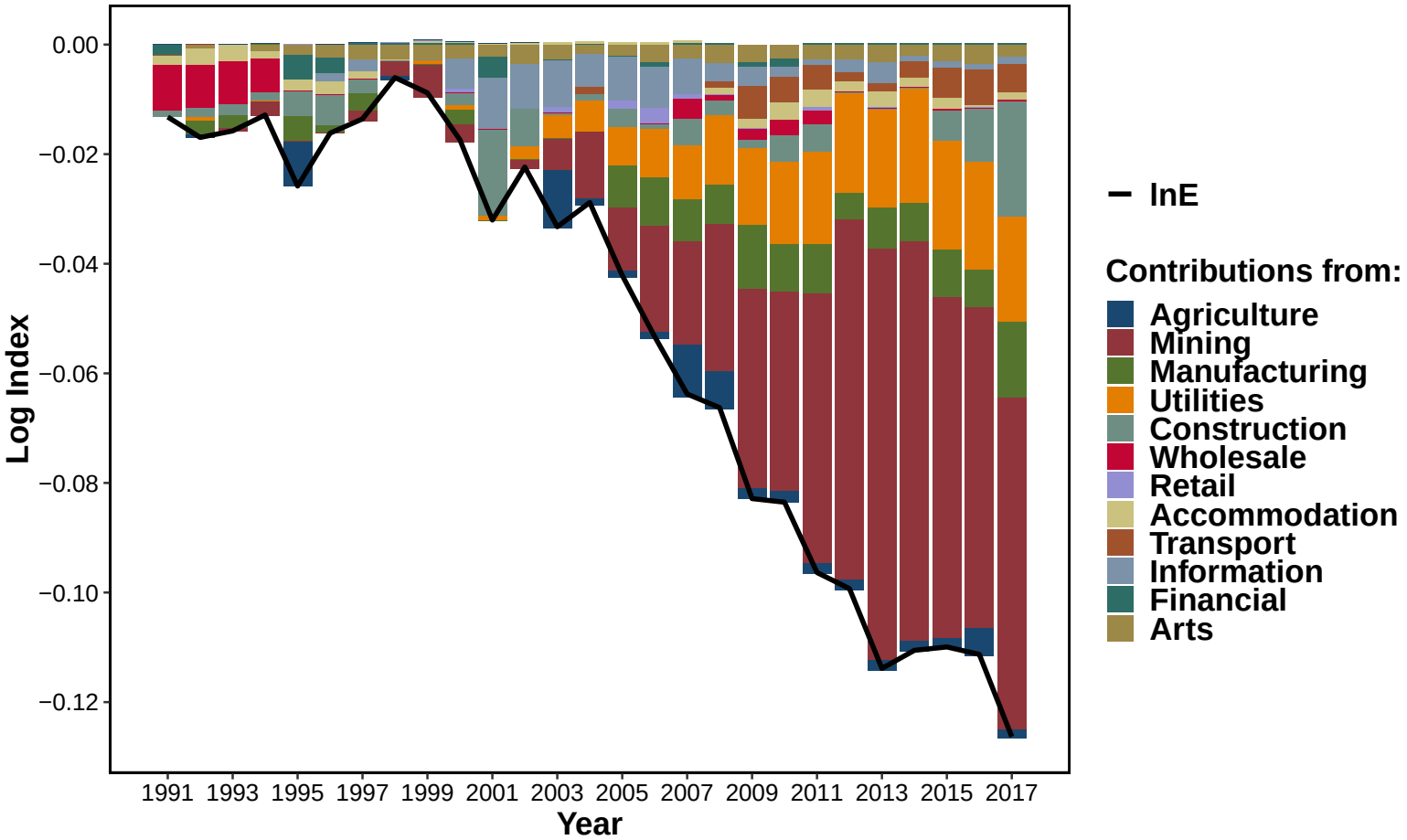
- From growth value to level value

$$\begin{aligned}
\ln \Lambda^{t\bullet} &= \sum_t \sum_k \frac{1}{2}(s^{kt} + s^{k,t-1}) \ln \lambda^{kt} \\
&= \sum_k \sum_t \frac{1}{2}(s^{kt} + s^{k,t-1}) \ln \lambda^{kt} \\
&= \sum_k \ln \Lambda^{kt}
\end{aligned}$$

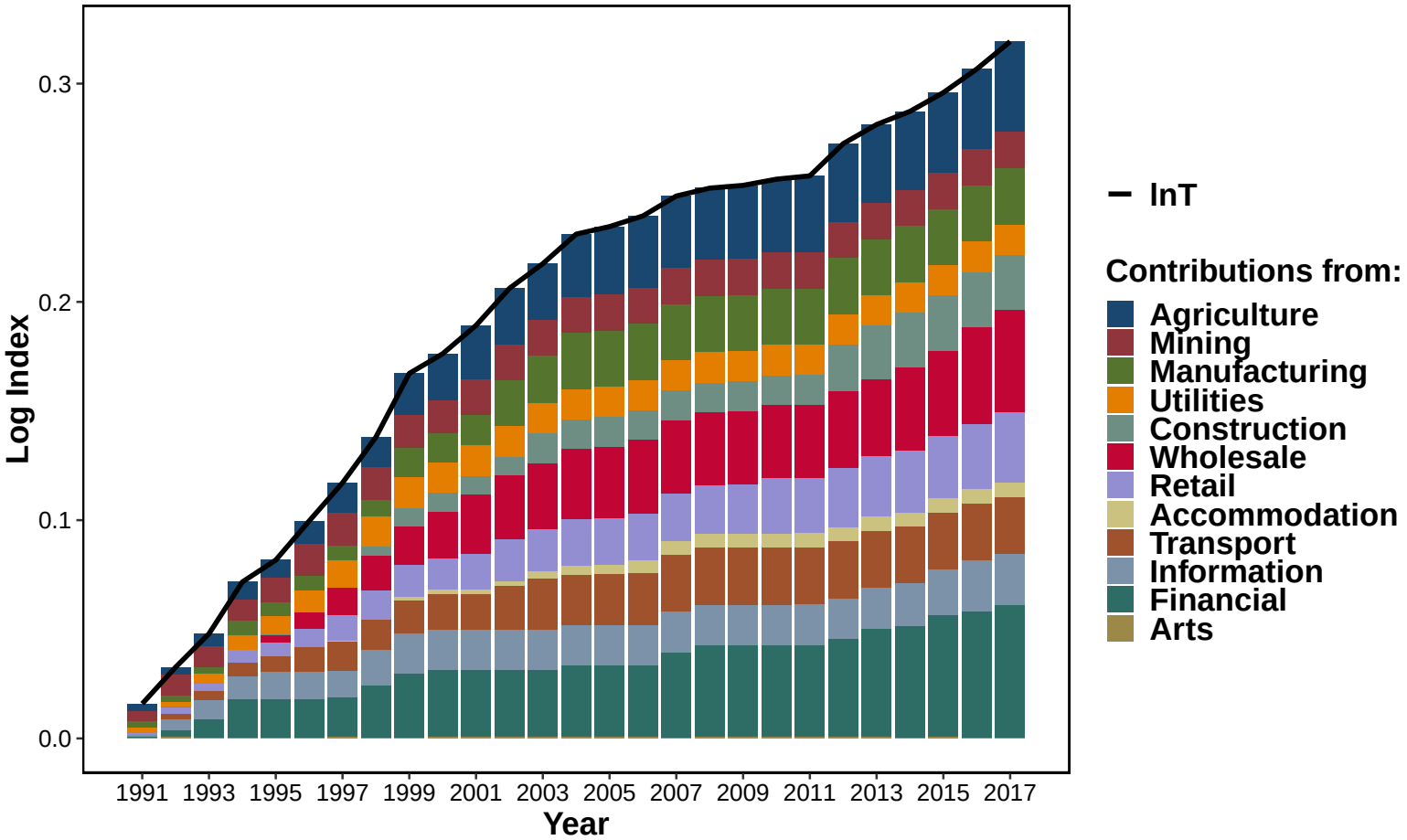
Industry contribution: productivity



Industry contribution: efficiency



Industry contribution: technical progress



Thoughts on the industry results

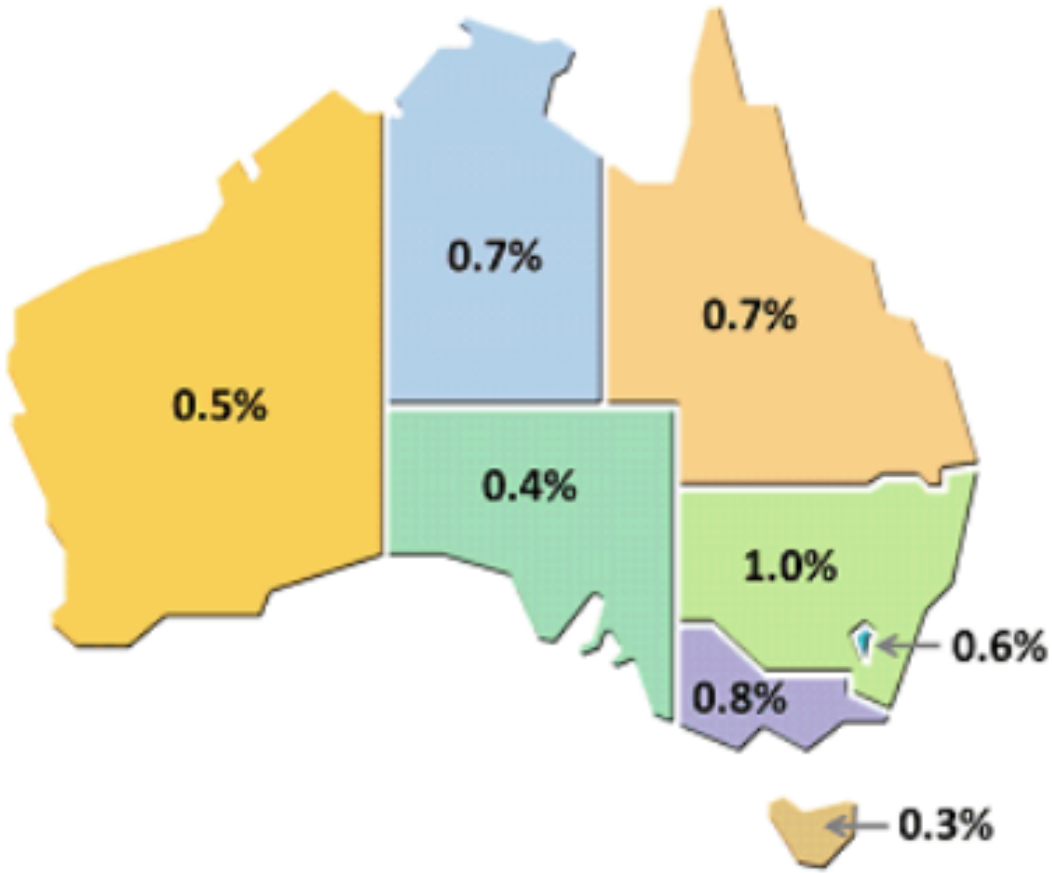
- Industry performance contributes to the aggregate level according to value added shares
- Efficiency
  - Unweighted: electricity, gas, water and waste services
  - Weighted: mining
- Technical progress
  - Unweighted: agriculture, forestry and fishing
  - Weighted: financial and insurance services

State-level data

- ABS published the first (experimental) estimates of state TFP in January 2018 for 1994/95 to 2016/17
- Data cover 12 selected industries (aggregate only)
- Less-populated states more prone to measurement error and volatility

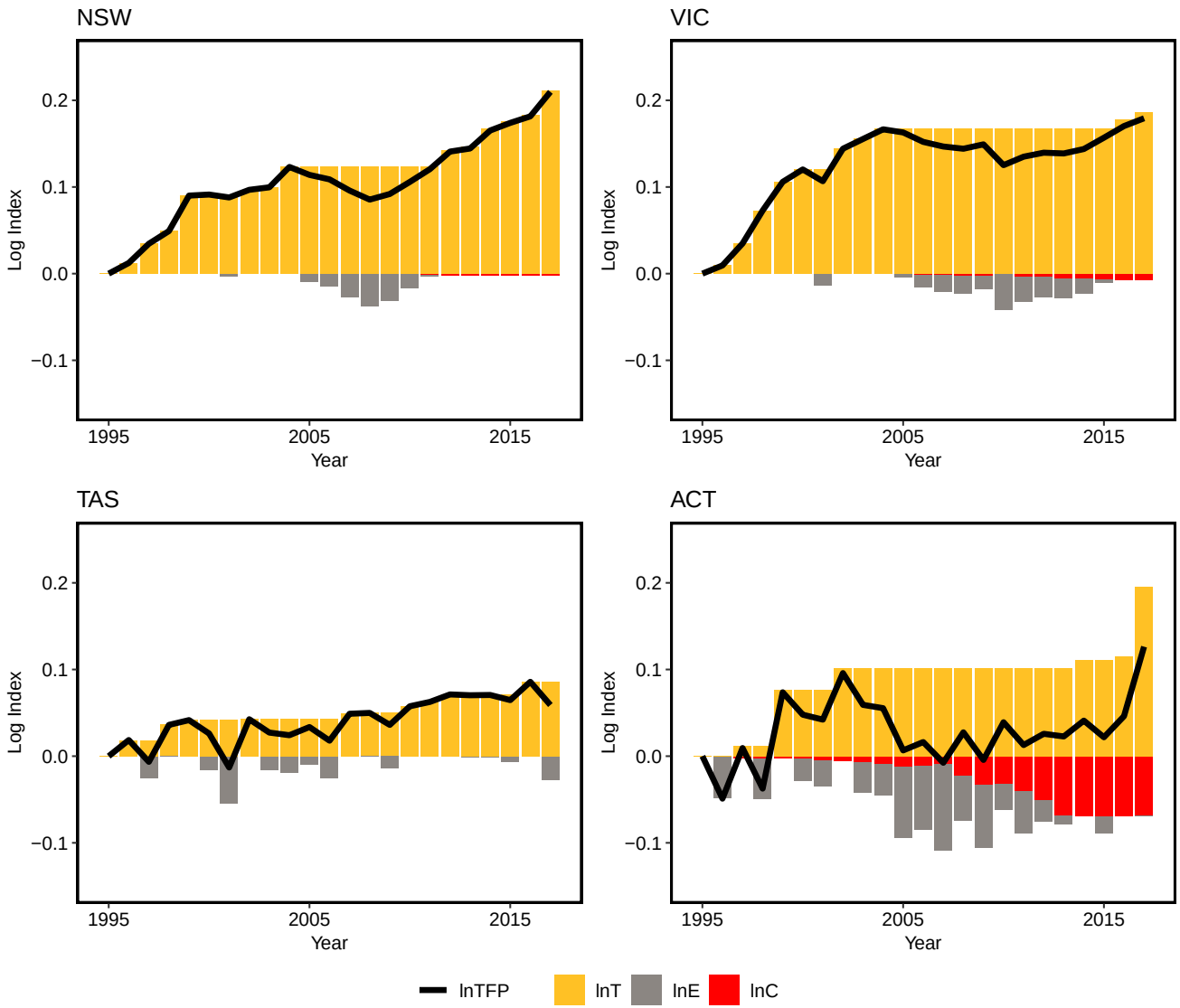
State-level TFP growth

Average TFP Growth by State, 1994/95-2016/17

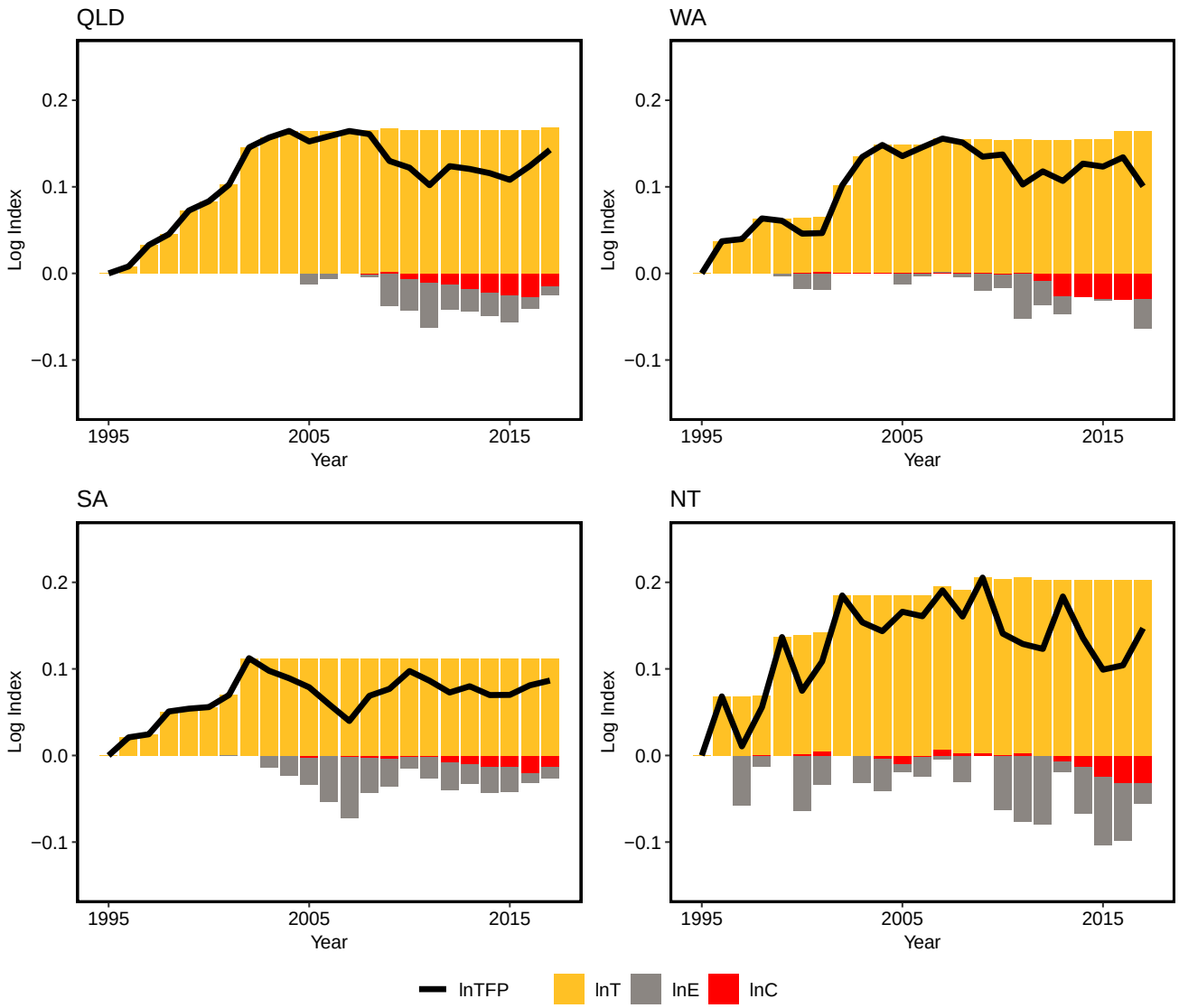


Source: ABS (2018)

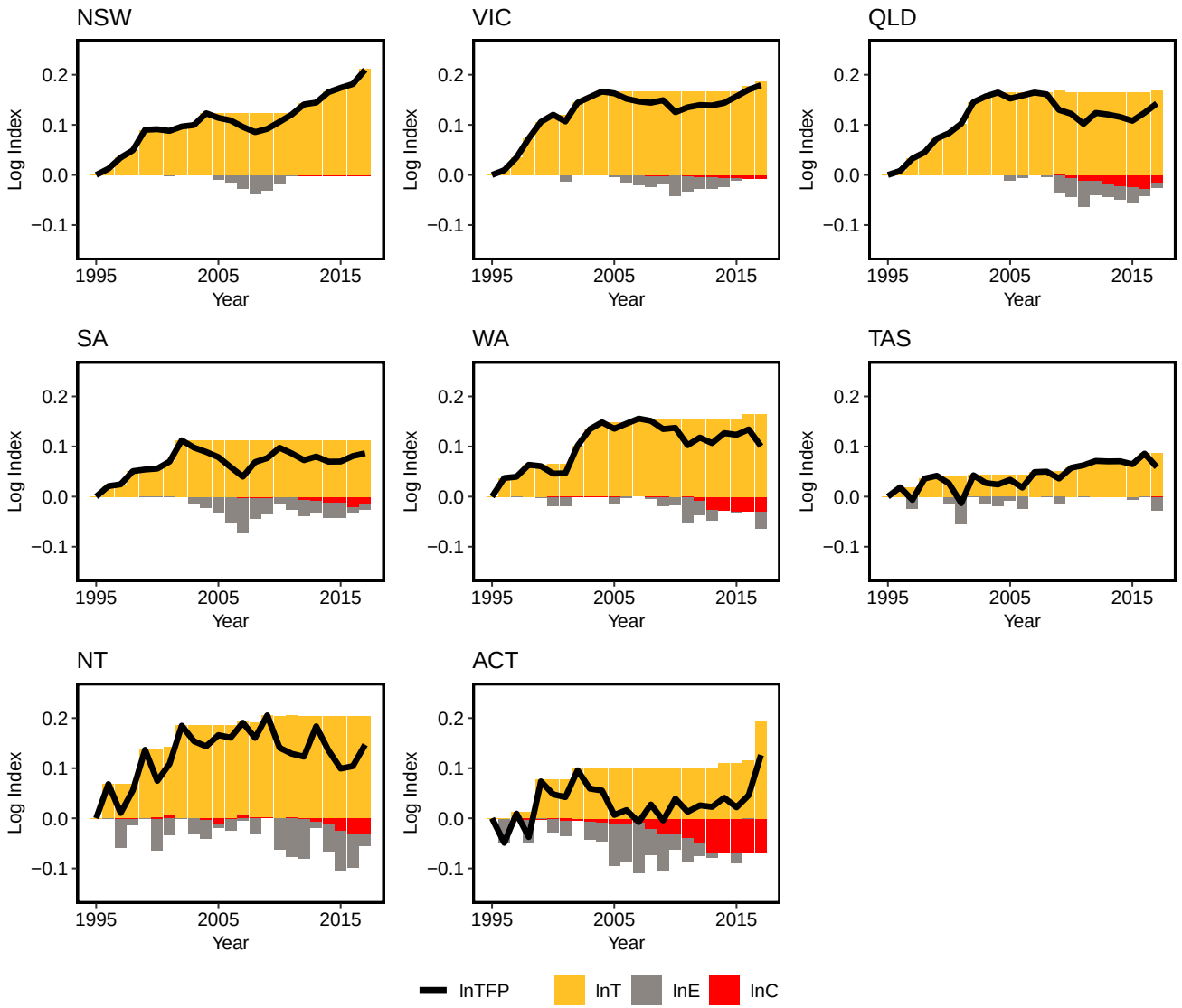
Non-mining states



Mining states



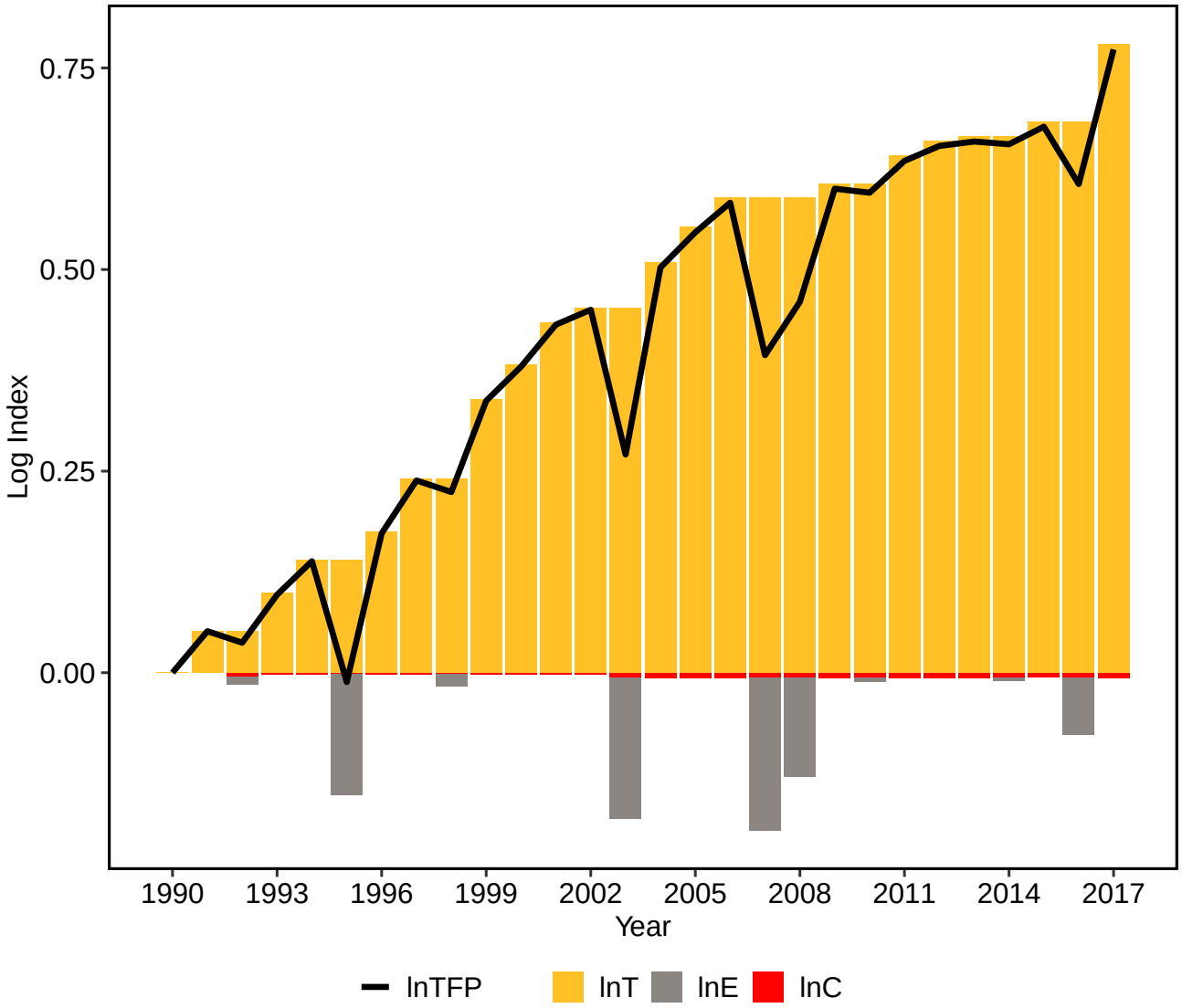
State-level decomposition



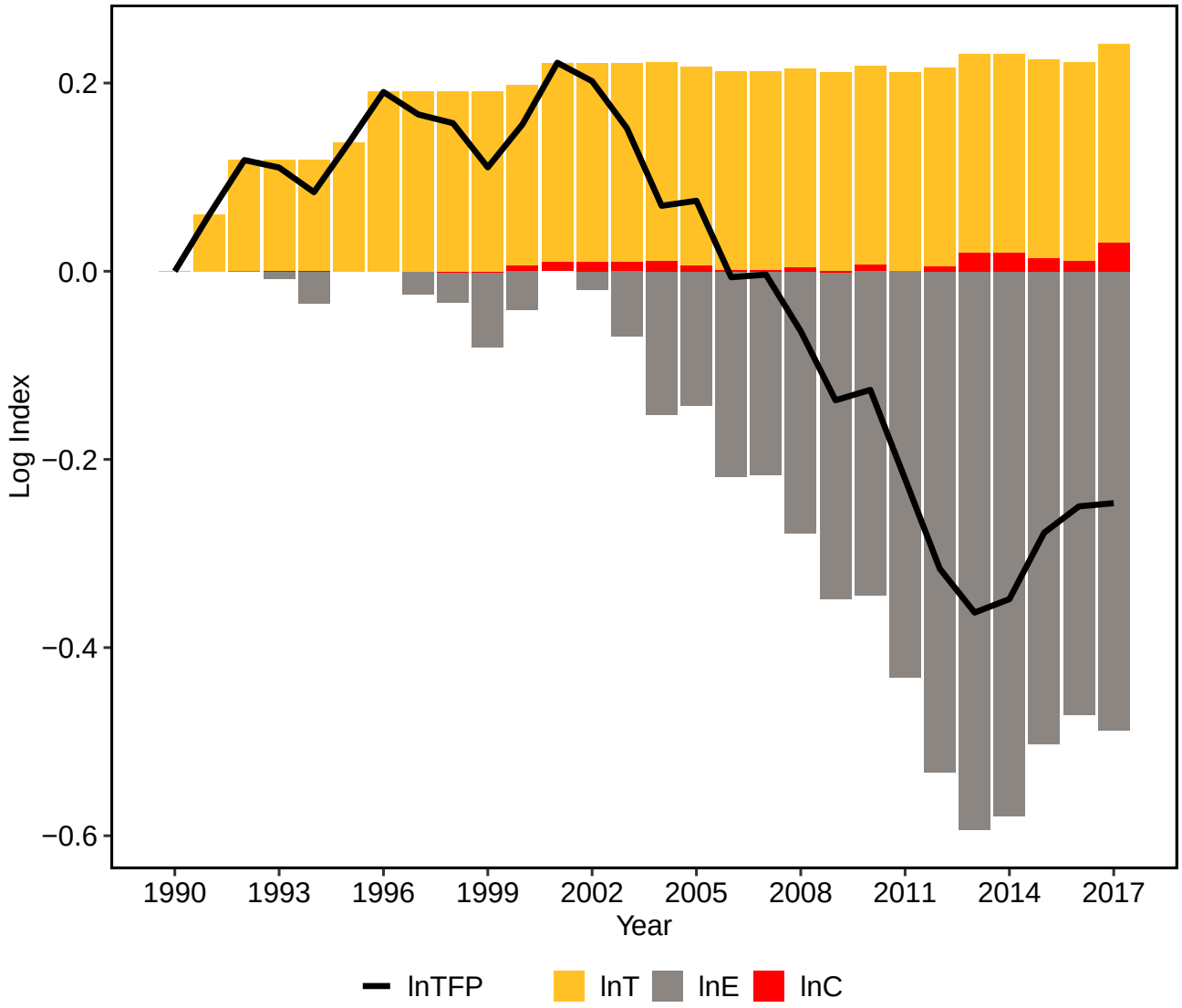
Conclusions

- We have used a new decomposition of industry value added growth, applied to official, publicly available data from the ABS
- The role of inefficiency proved to be very large for many industries and states
  - We think that this result is more reasonable than simply interpreting negative TFP growth as technological regress
  - Industries and states with huge amounts of inefficiency should be investigated for possible mismeasurement of the underlying inputs and outputs
- Our method is easily implementable by national statistical offices and provides policy-relevant information on growth and productivity

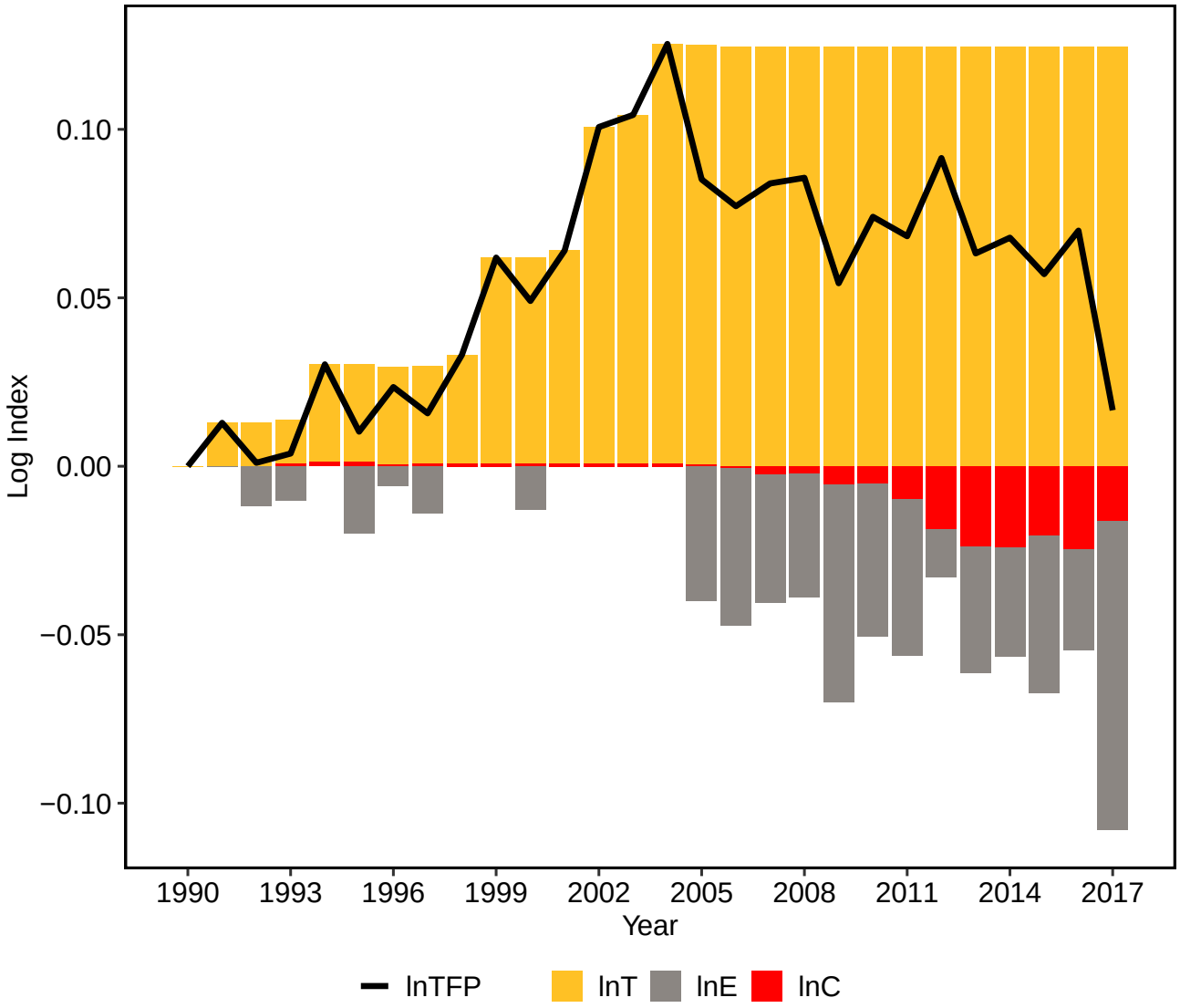
Agriculture, Forestry and Fishing



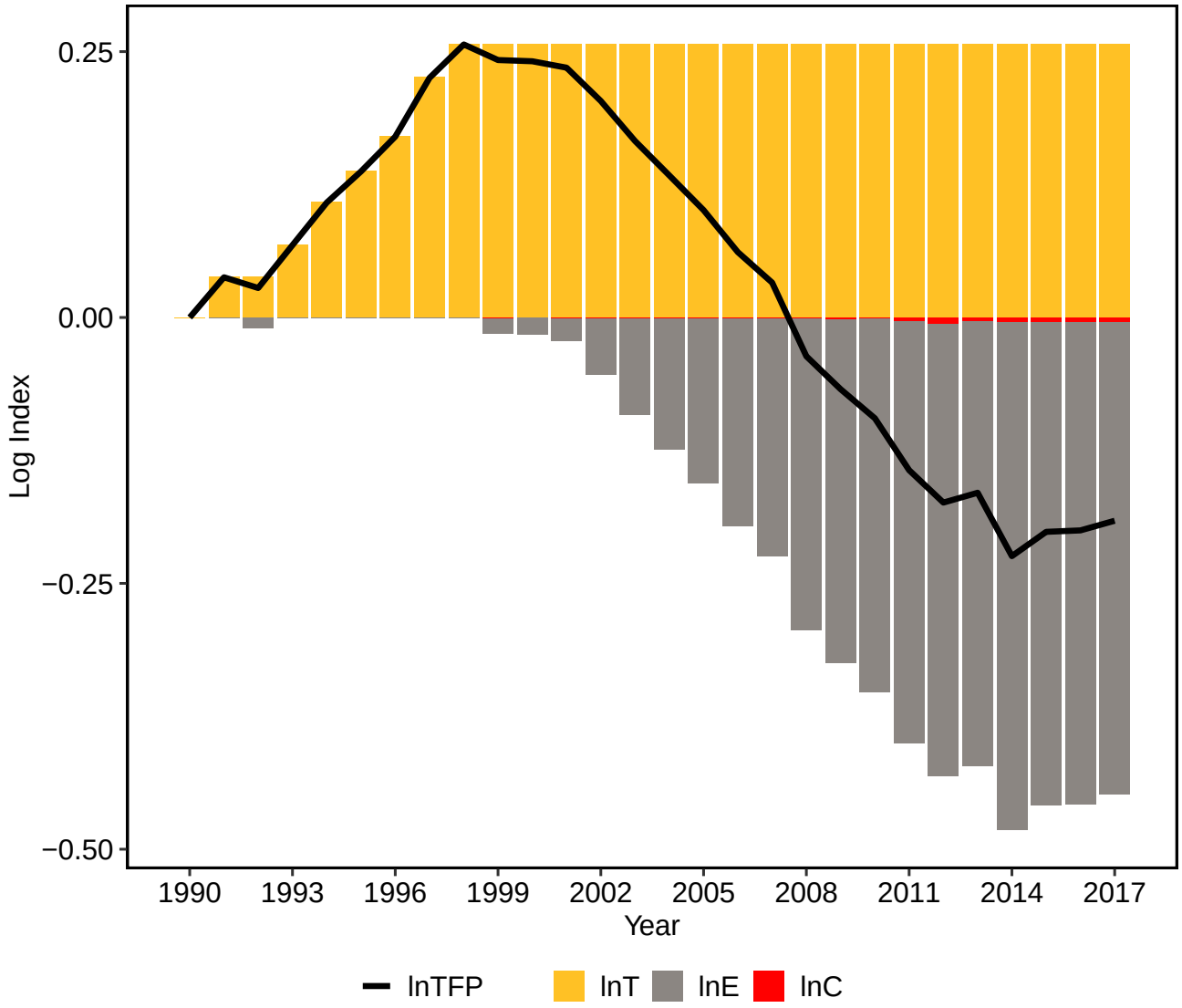
Mining


0.2
0.0
−0.2
−0.4
−0.6
Log Index
1990
1993
1996
1999
2002
2005
2008
2011
2014
2017
Year
lnTFP
lnT
lnE
lnC

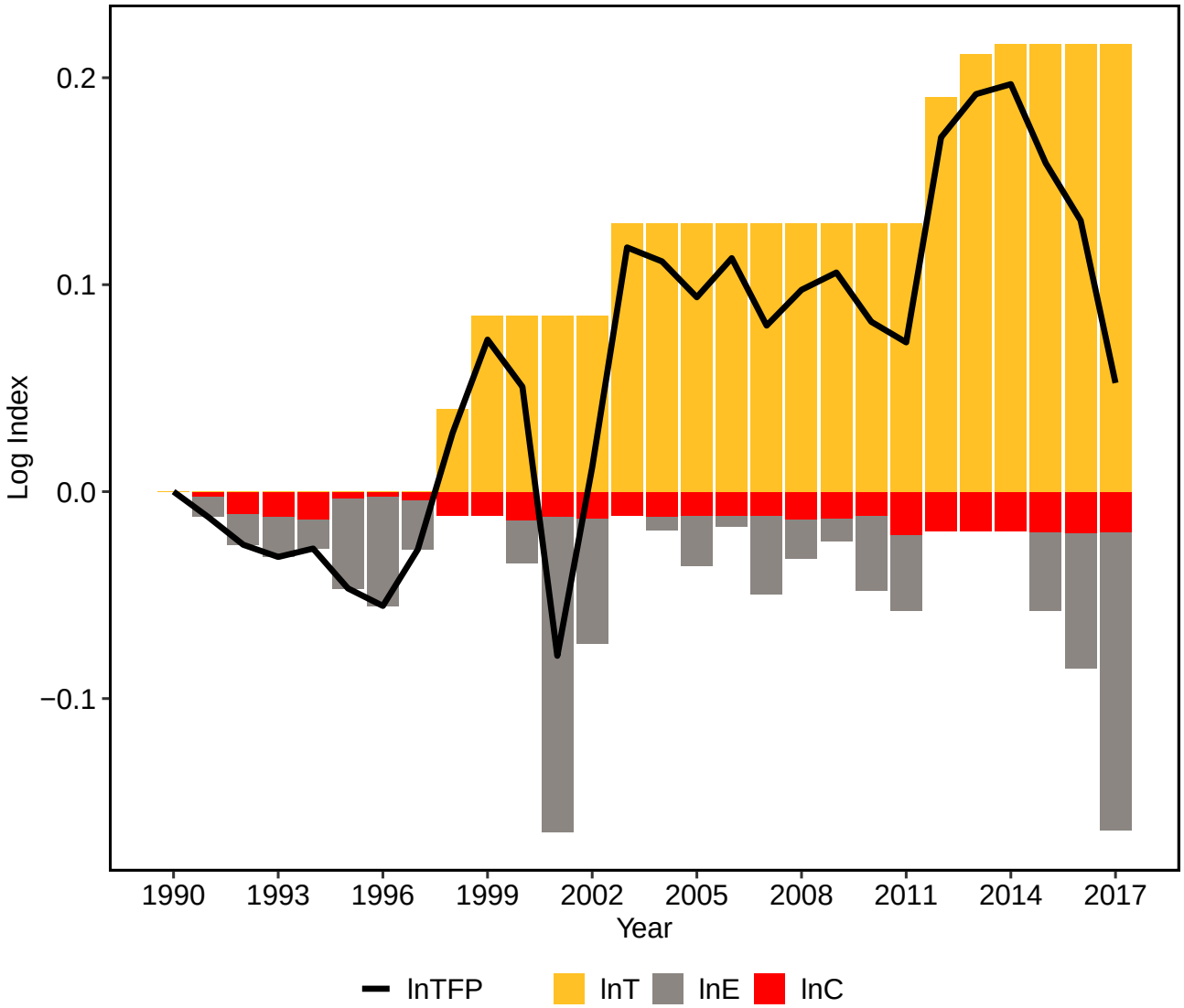
Manufacturing



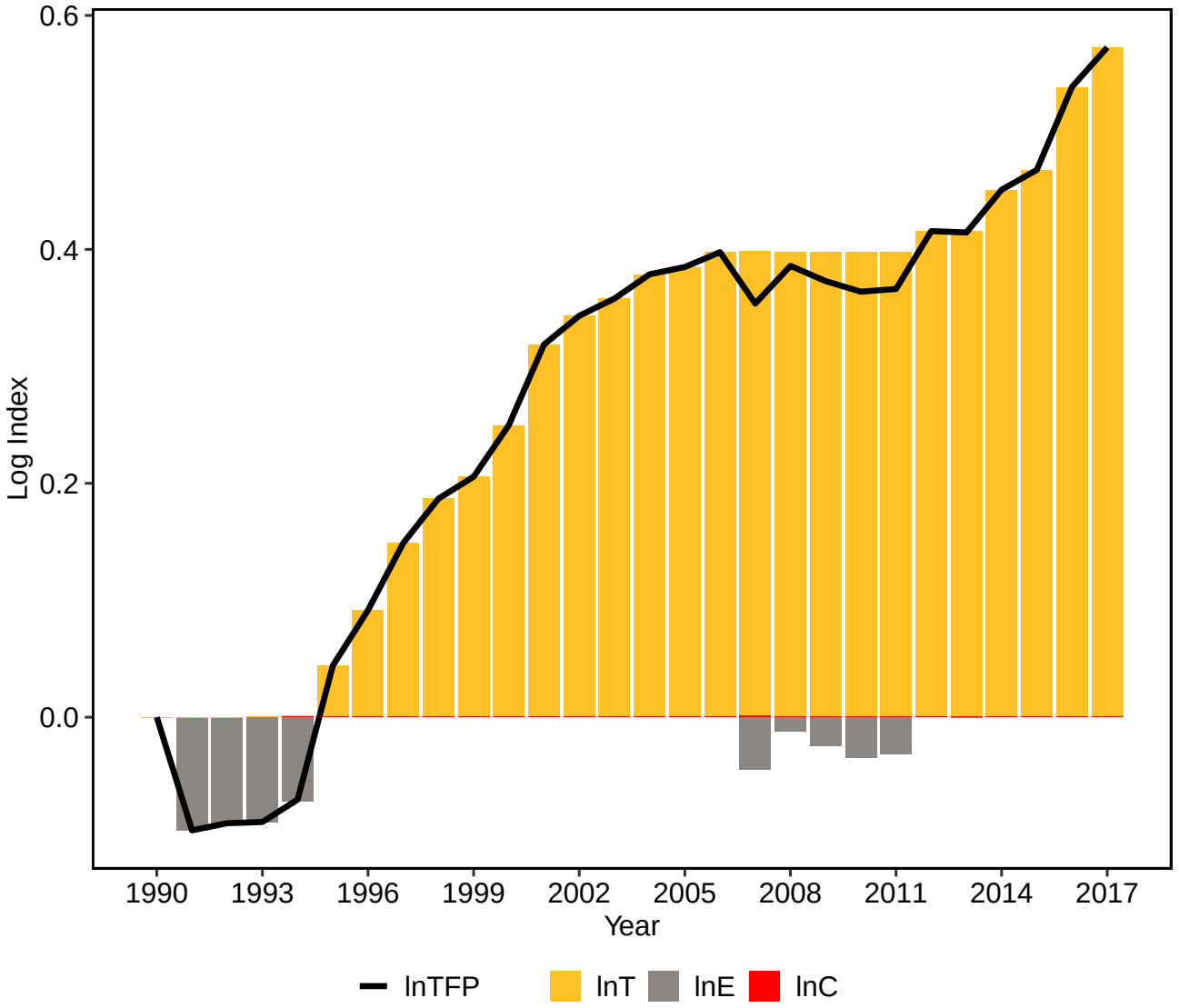
Electricity, Gas, Water and Waste Services



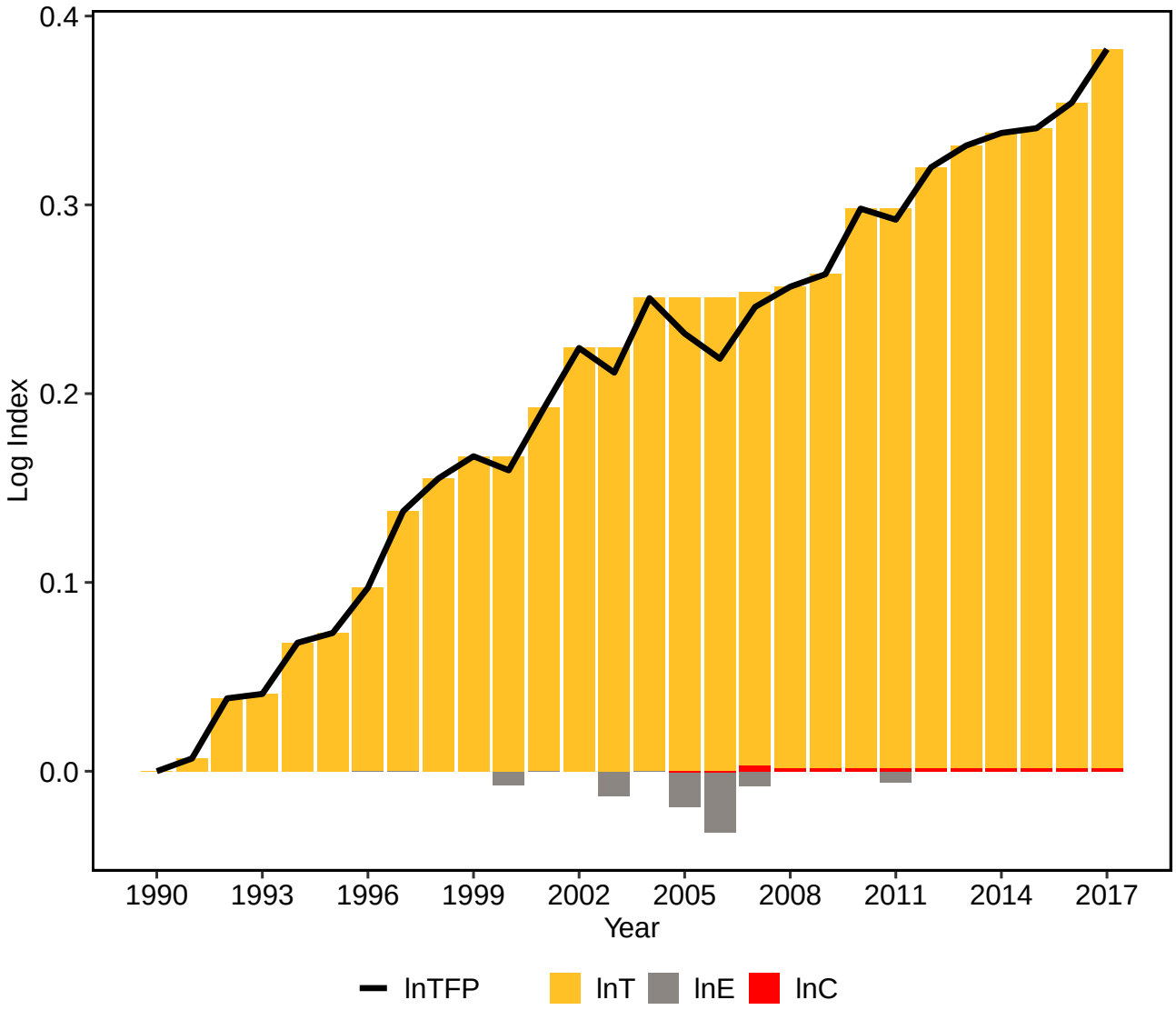
Construction



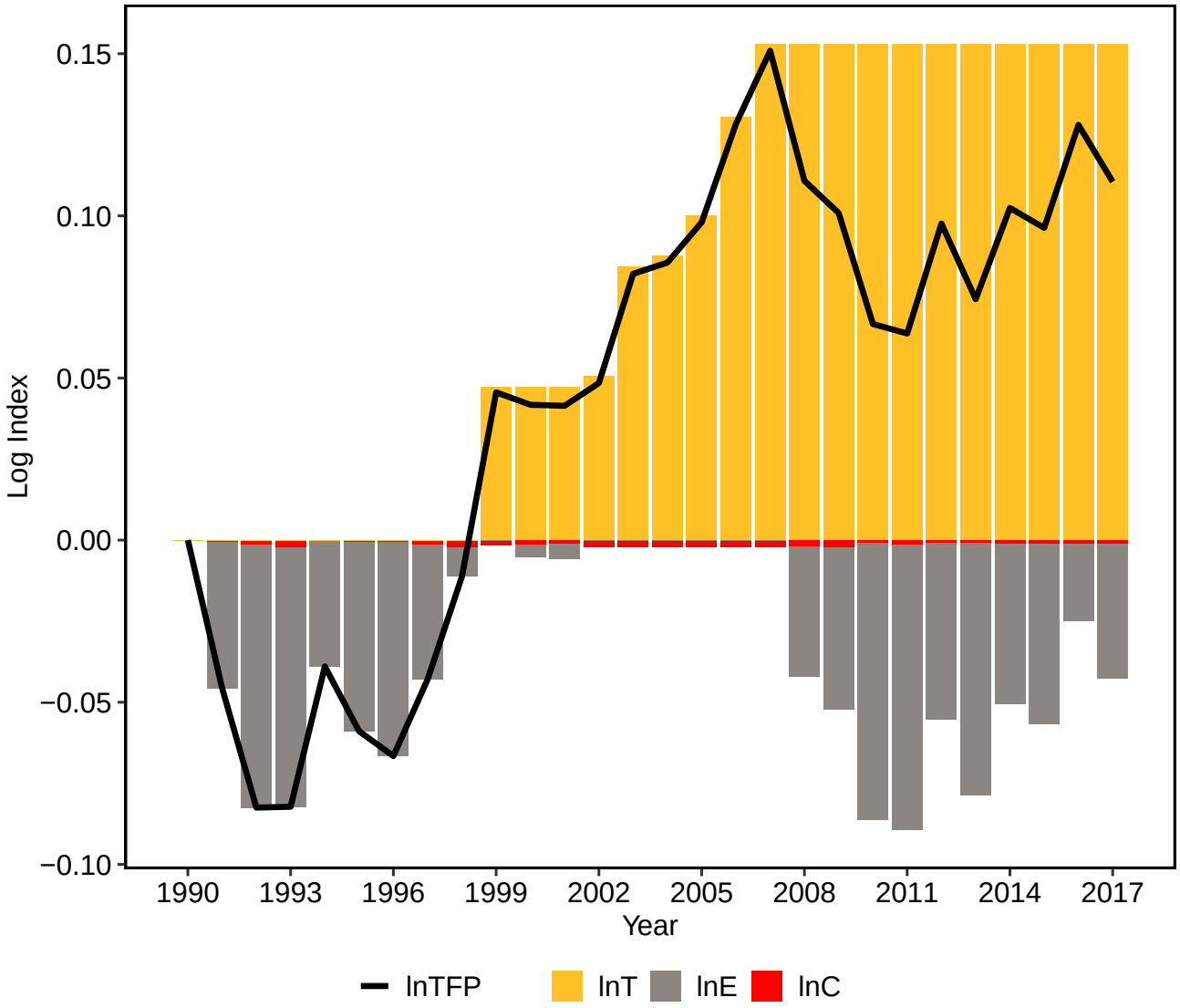
Wholesale Trade



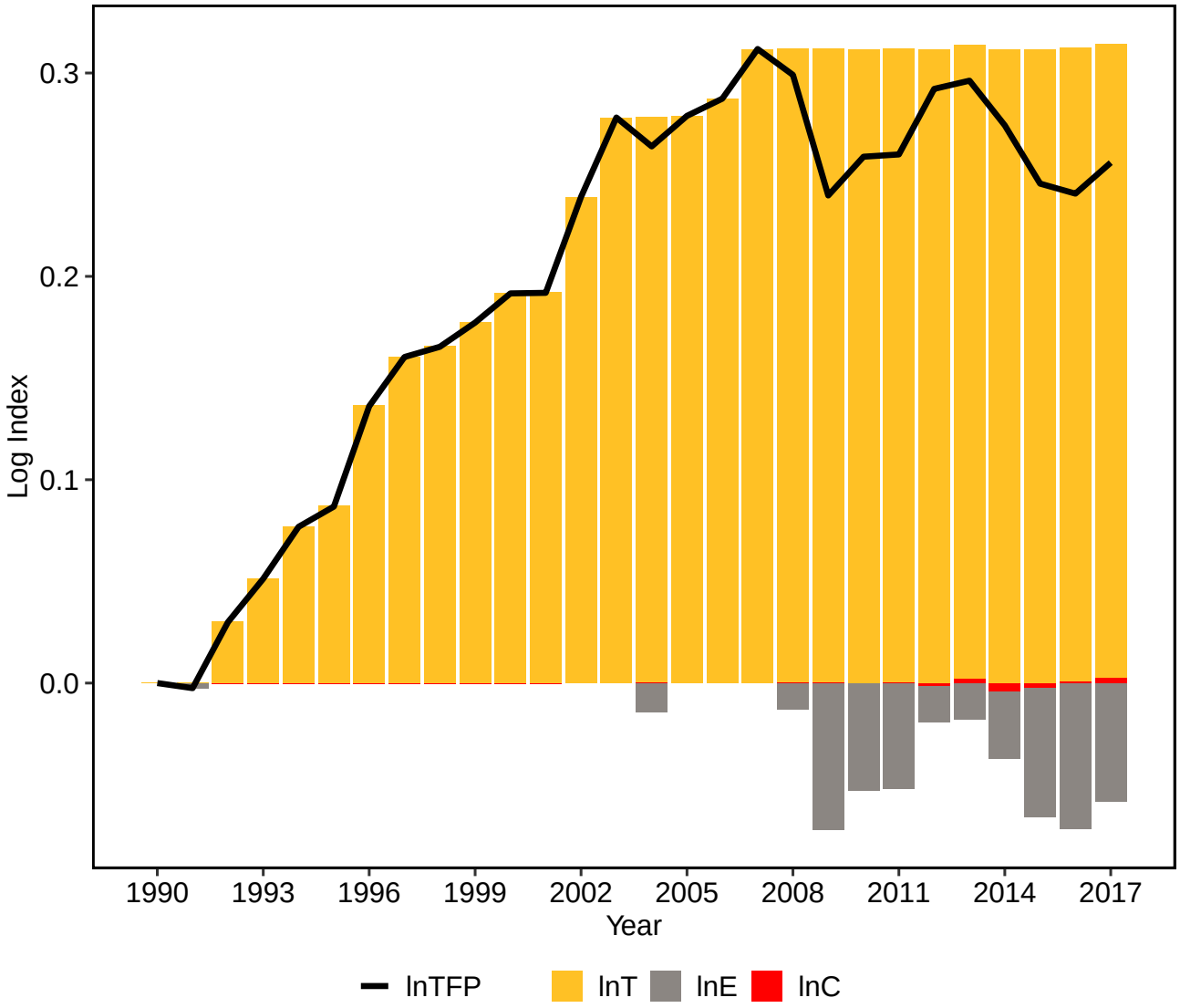
Retail Trade



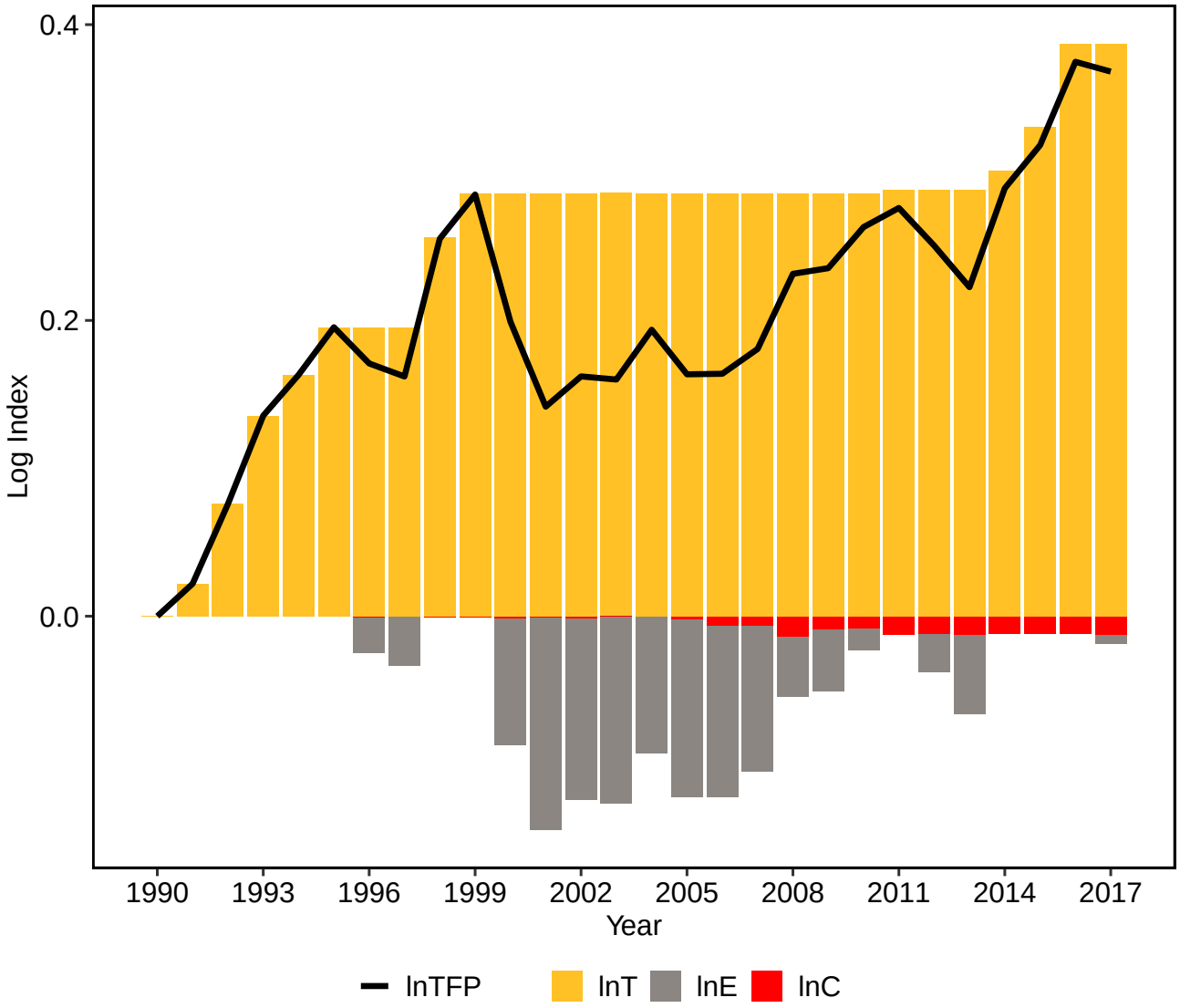
Accommodation and Food Services



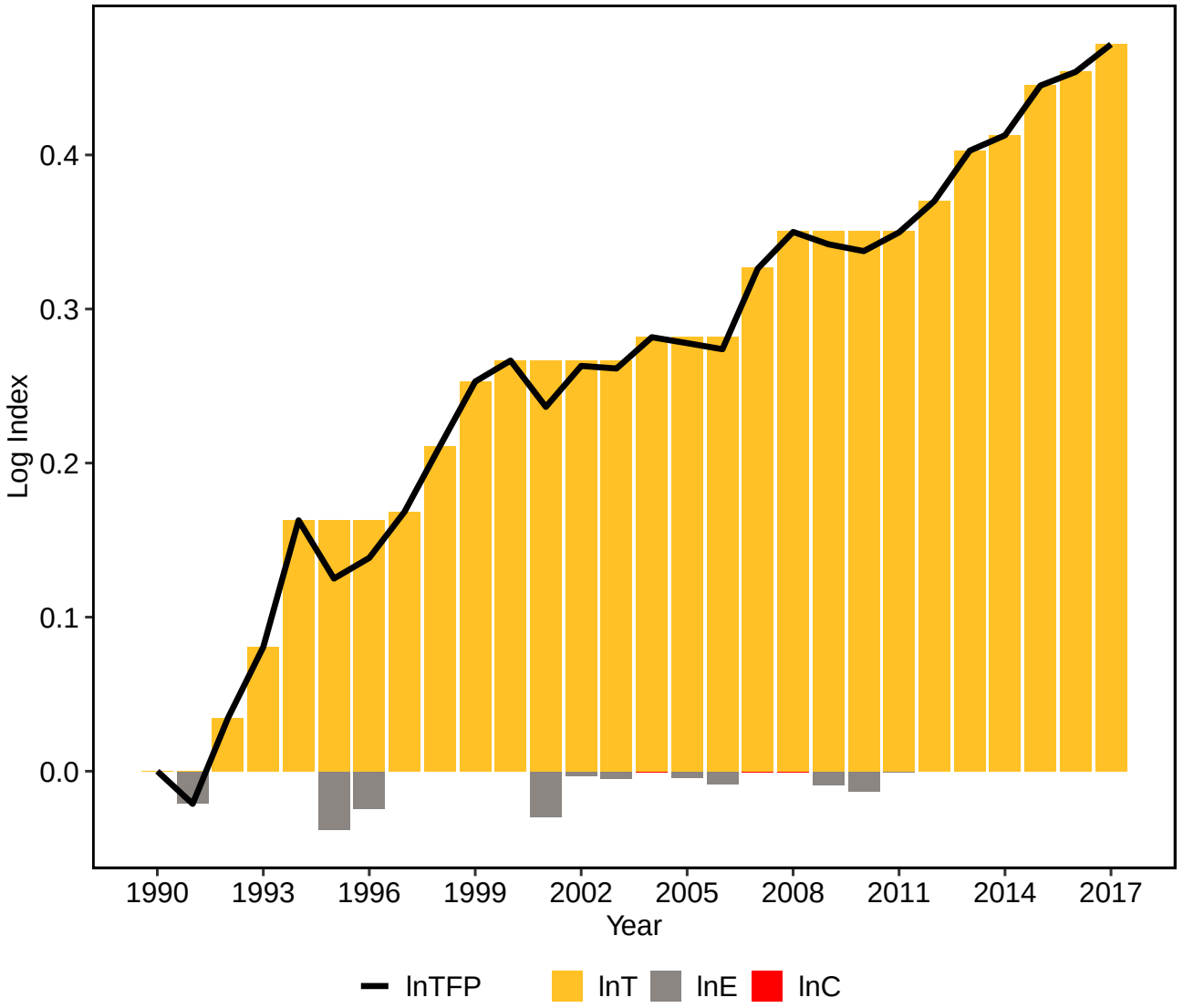
Transport, Postal and Warehousing



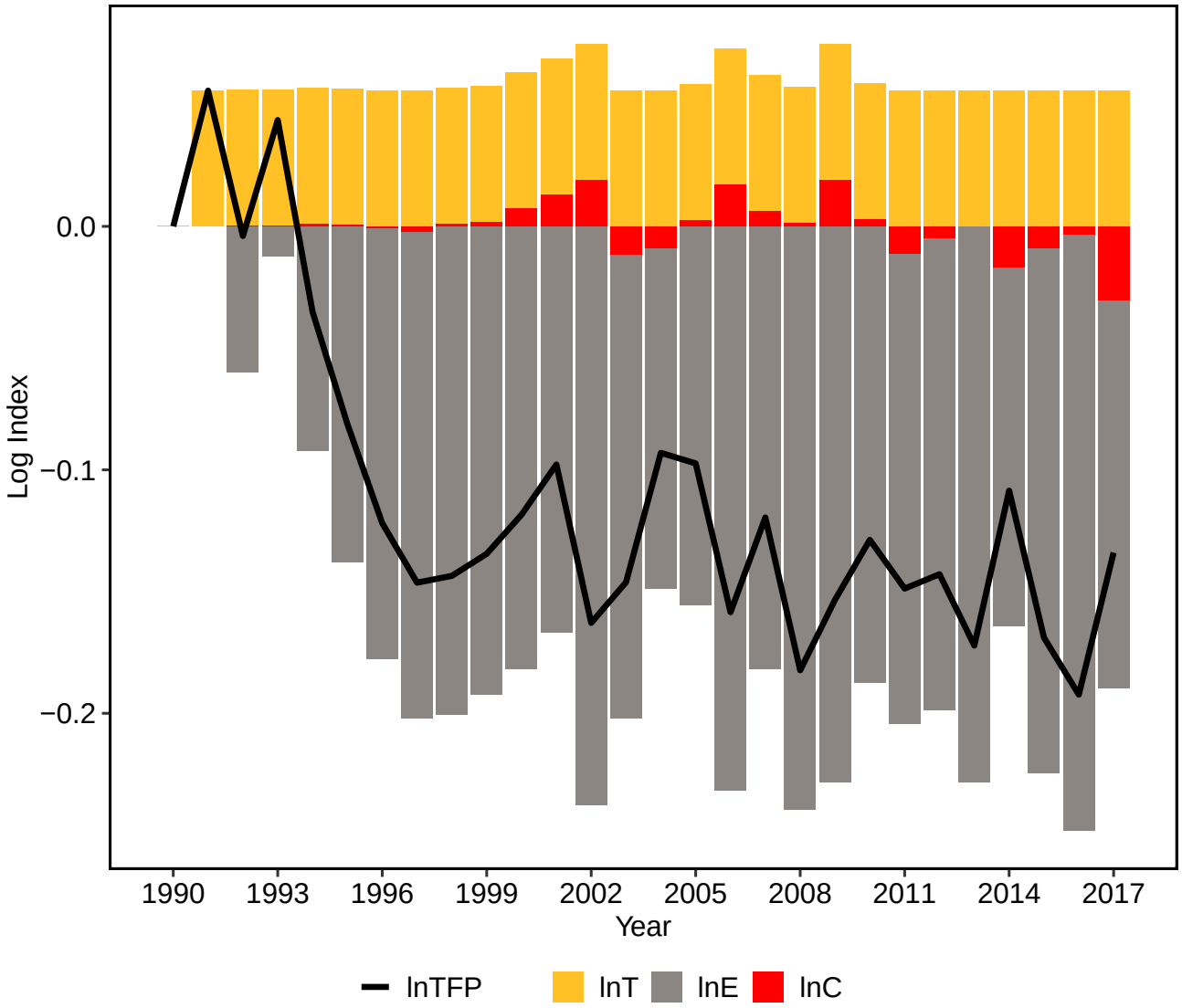
Information, Media and Telecommunications



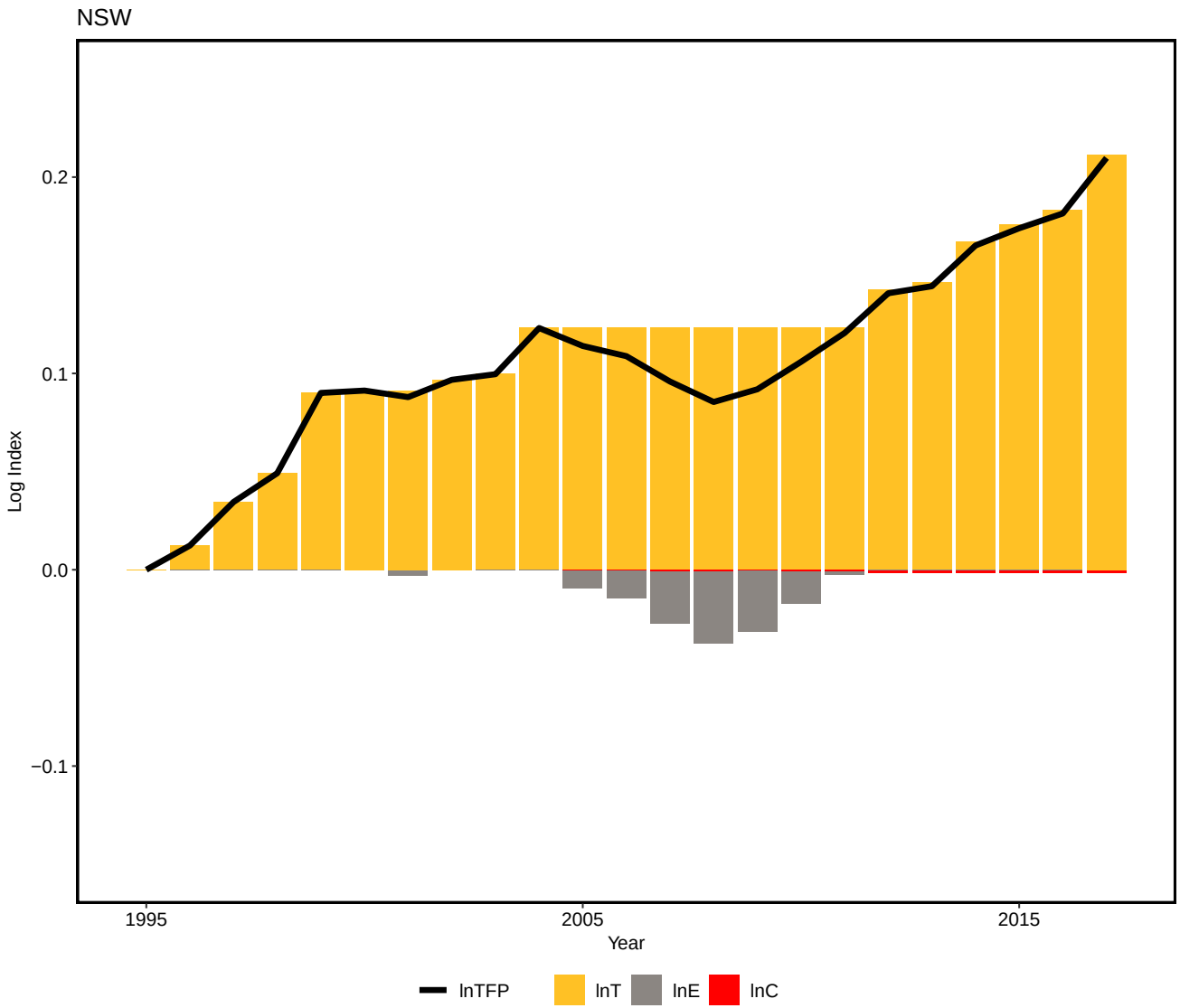
Financial and Insurance Services



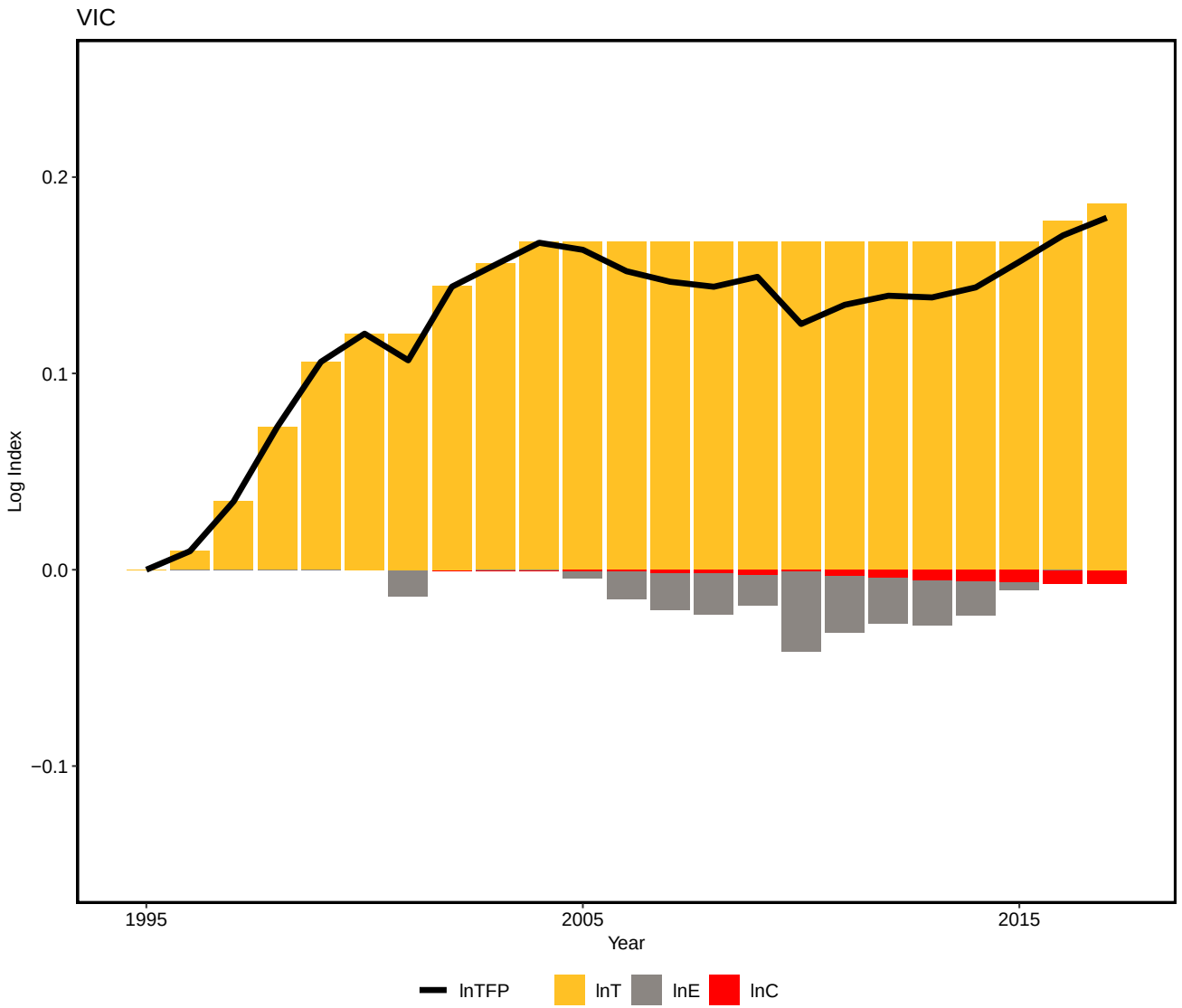
Arts and Recreation Services



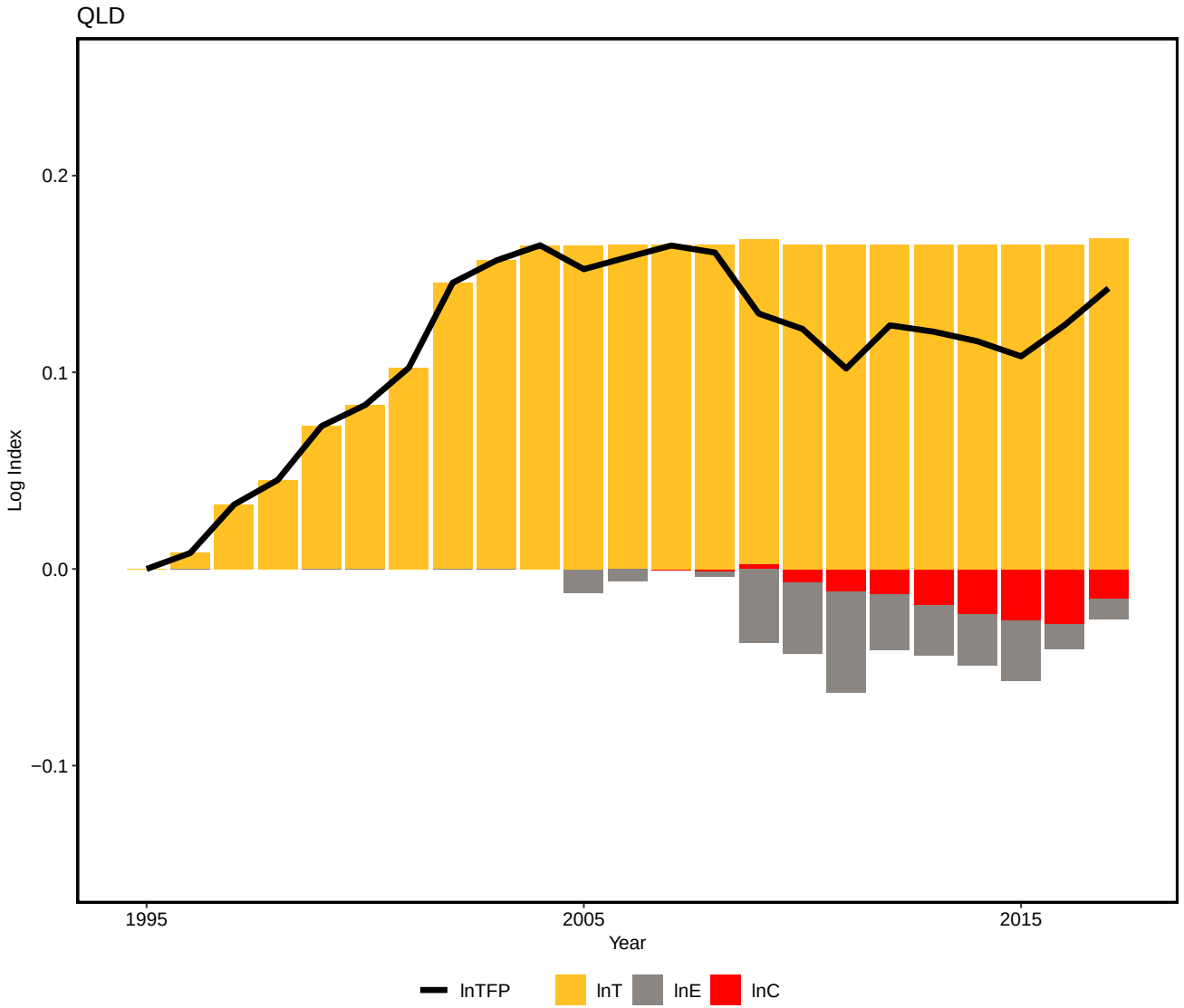
New South Wales



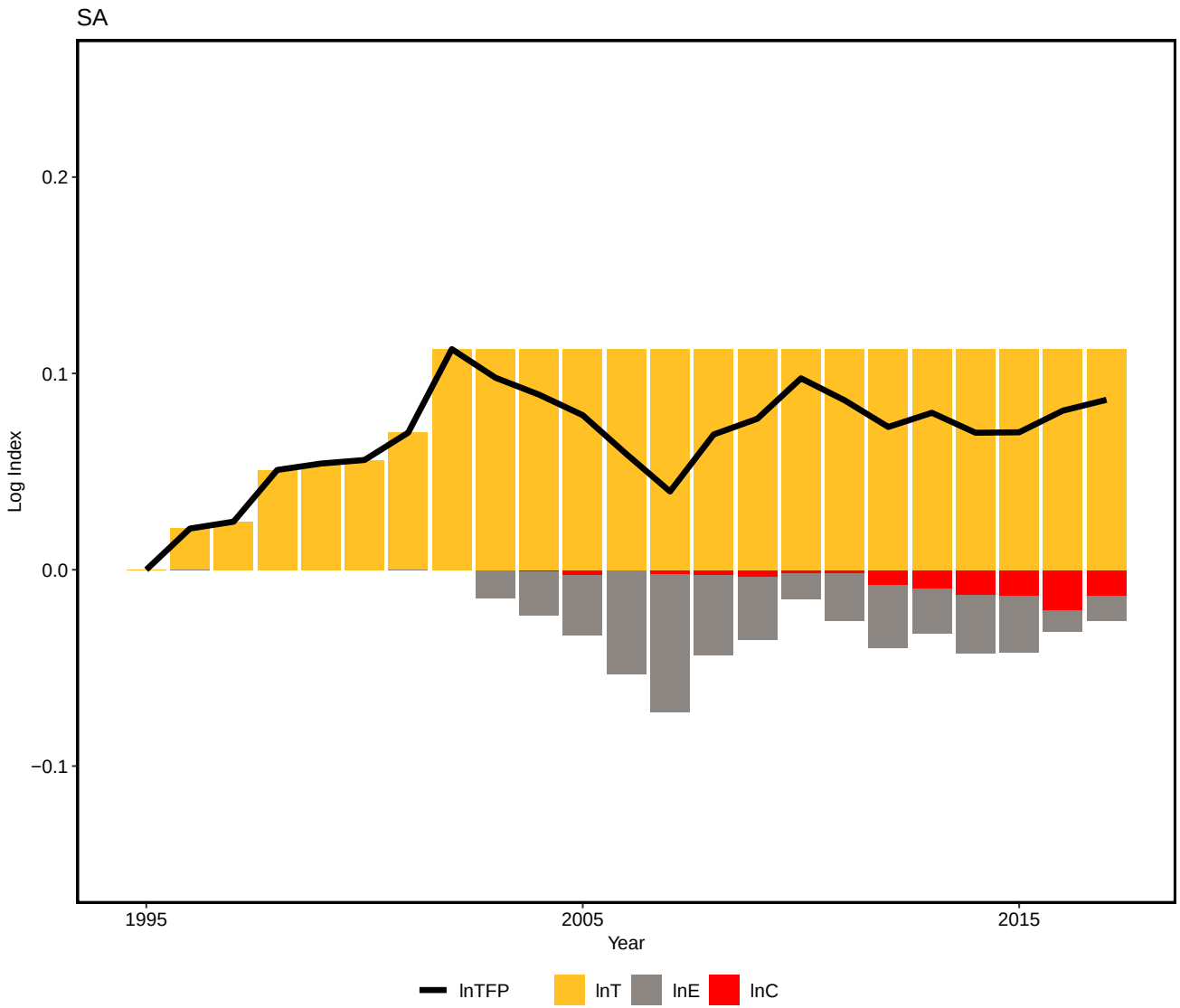
Victoria



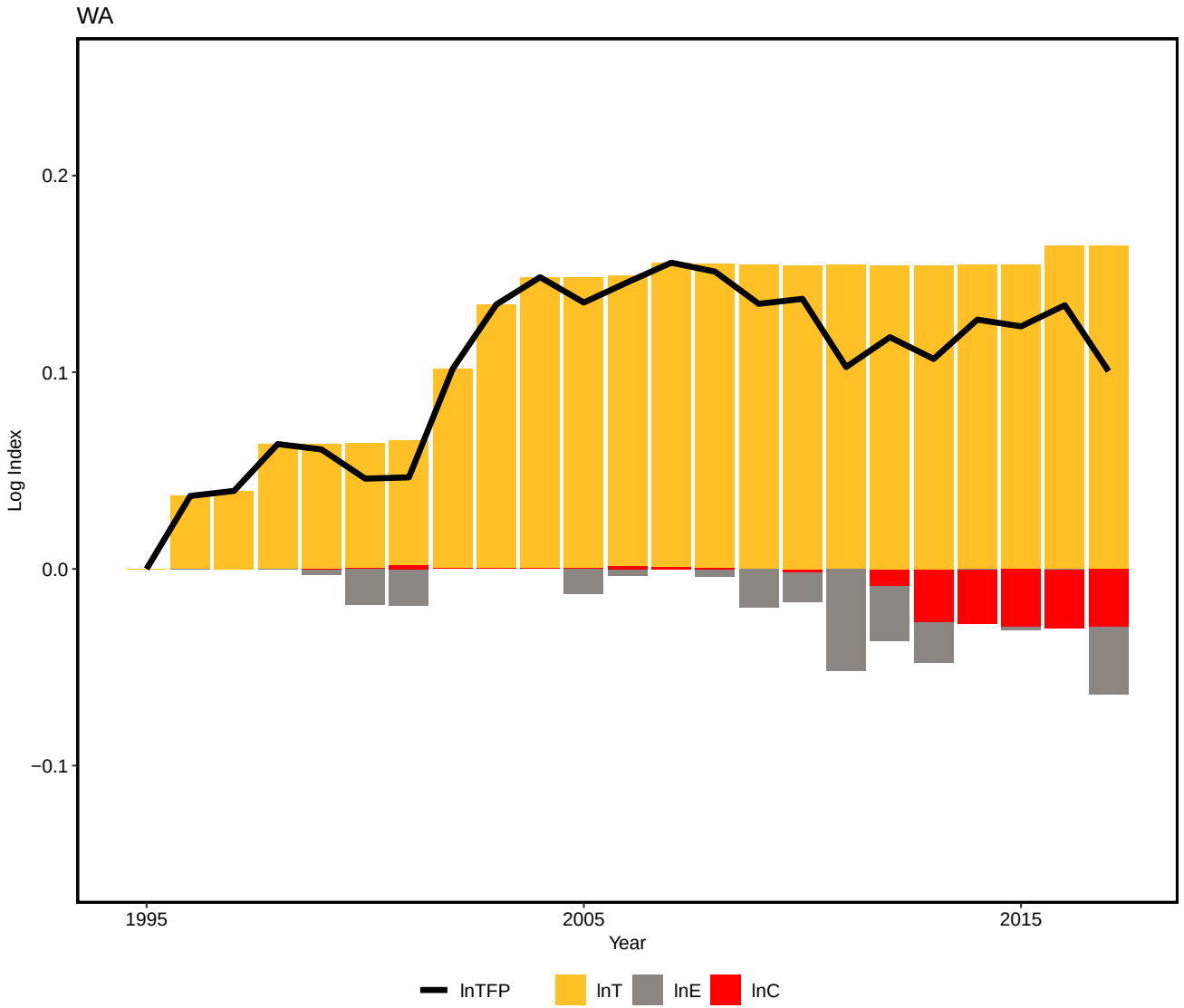
Queensland



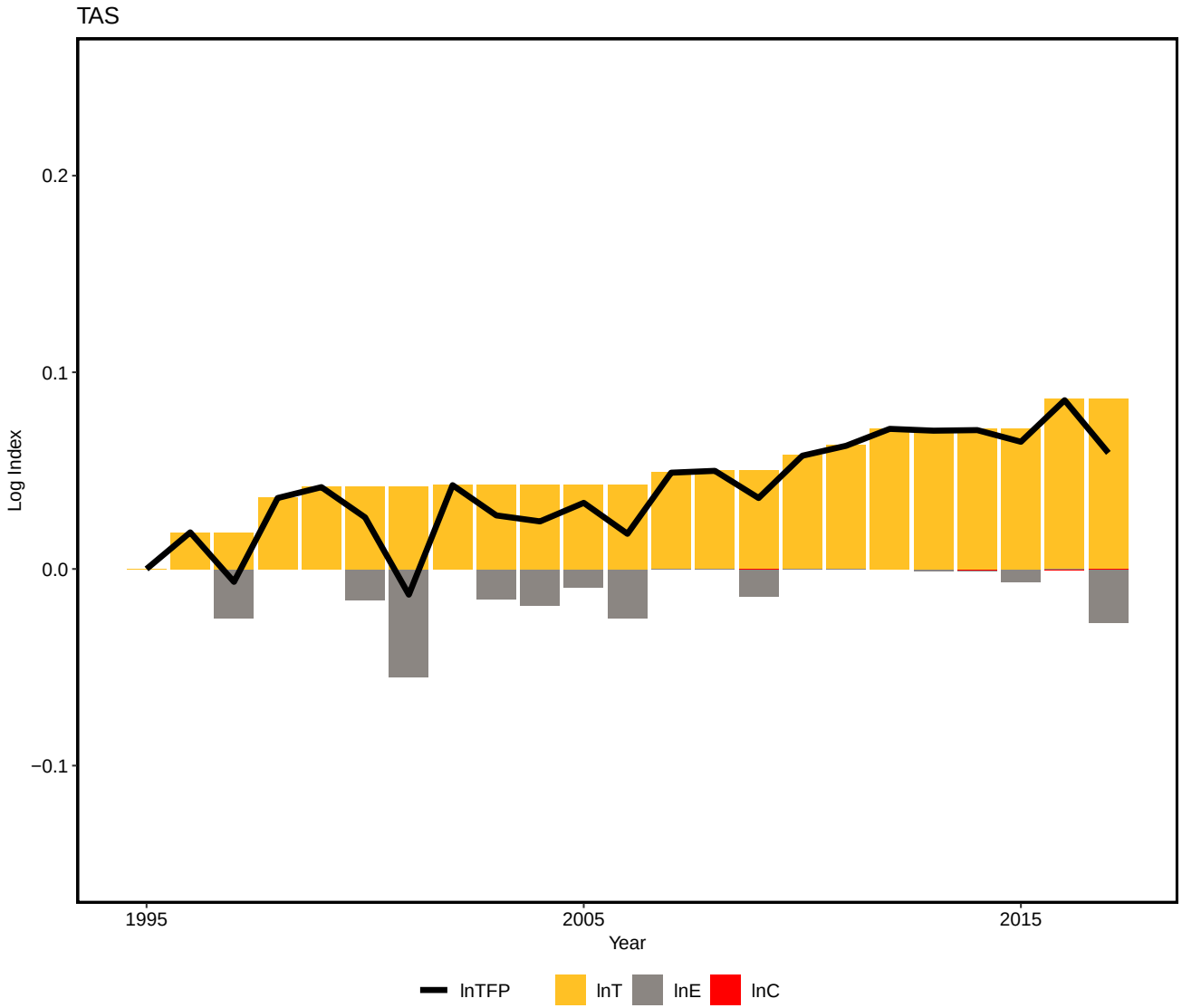
South Australia



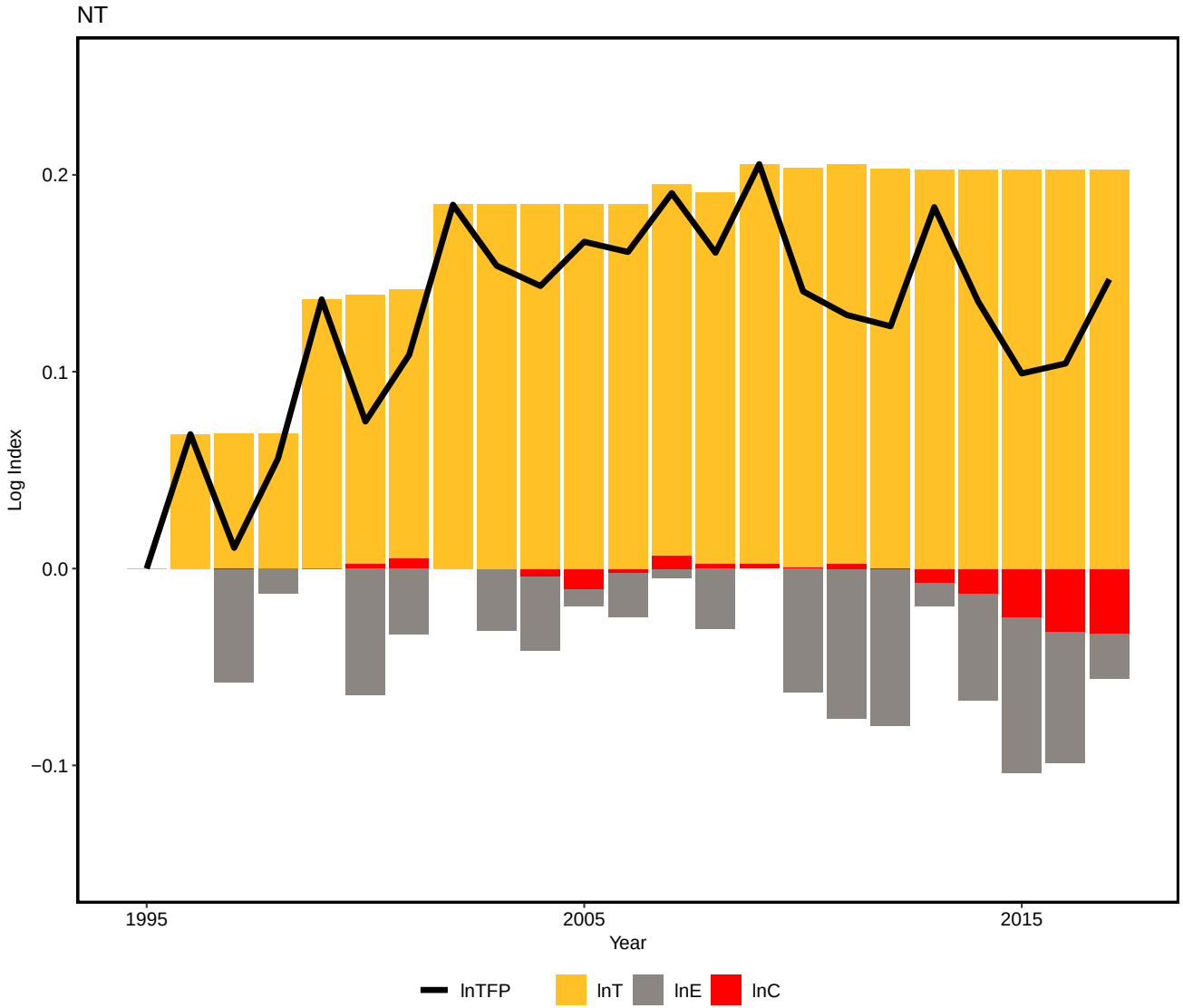
Western Australia



Tasmania



Northern Territory



Australian Capital Territory